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Muroi et al.

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(54) **TIME SWITCH**

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(52) **U.S. Cl.** .... **200/38 D**; 200/35 R; 200/38 R; 200/38 A; 200/38 F; 200/38 B
(58) **Field of Search** 200/33 R–40

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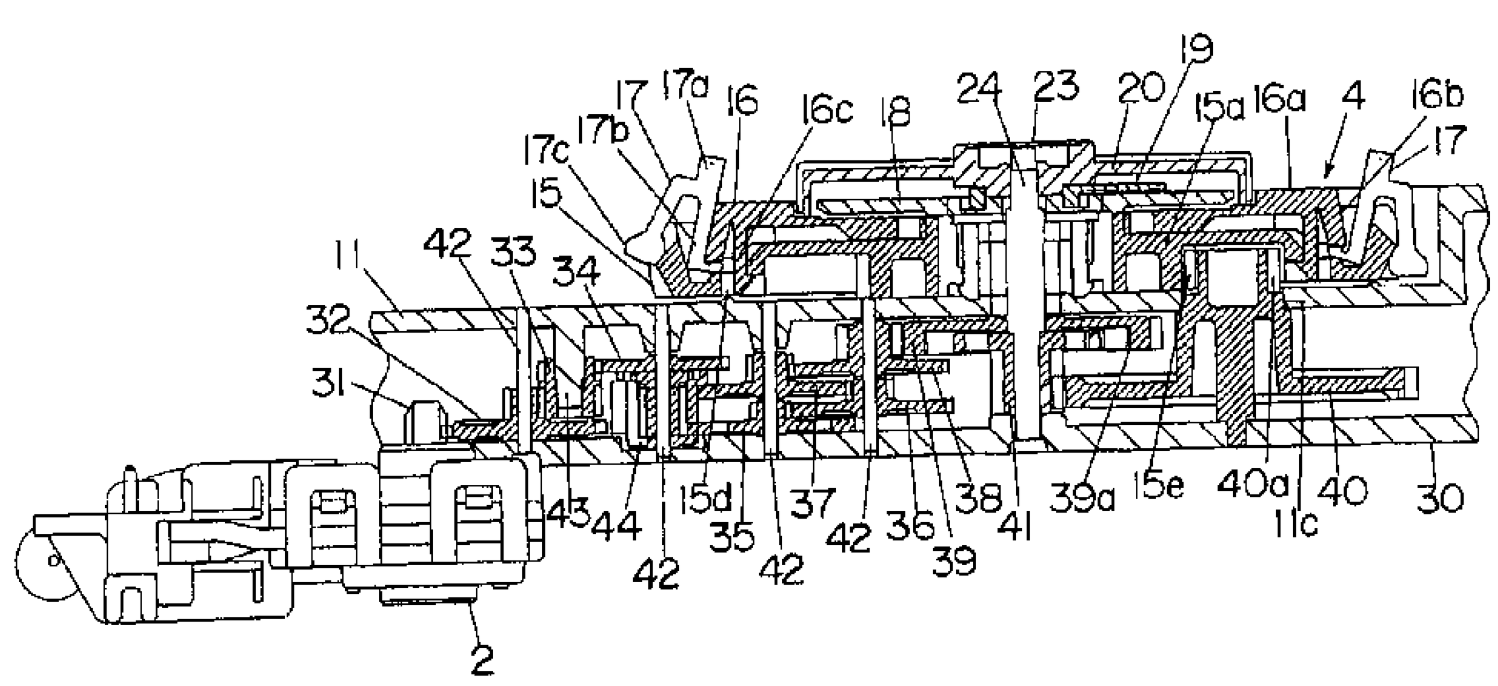
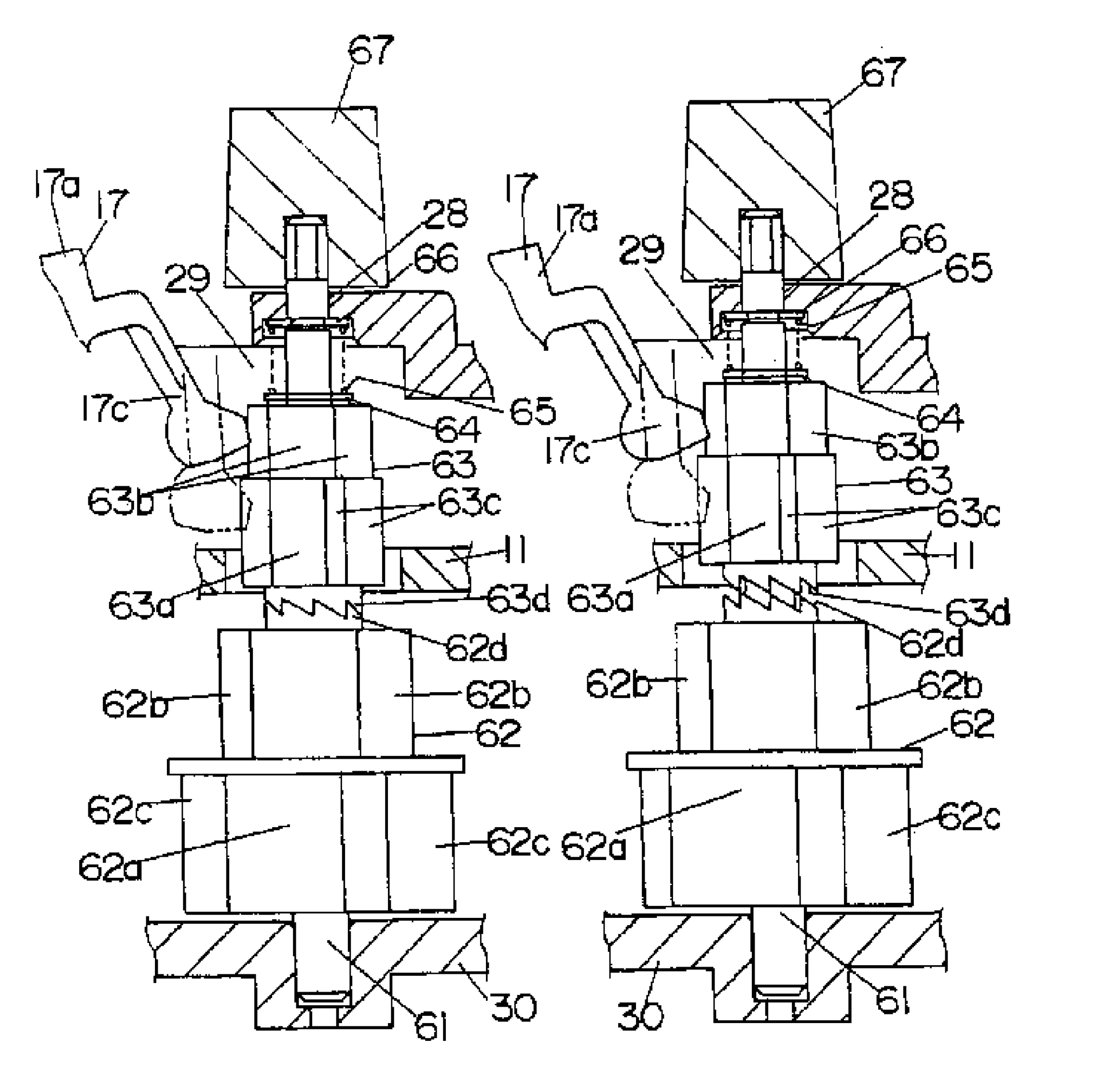
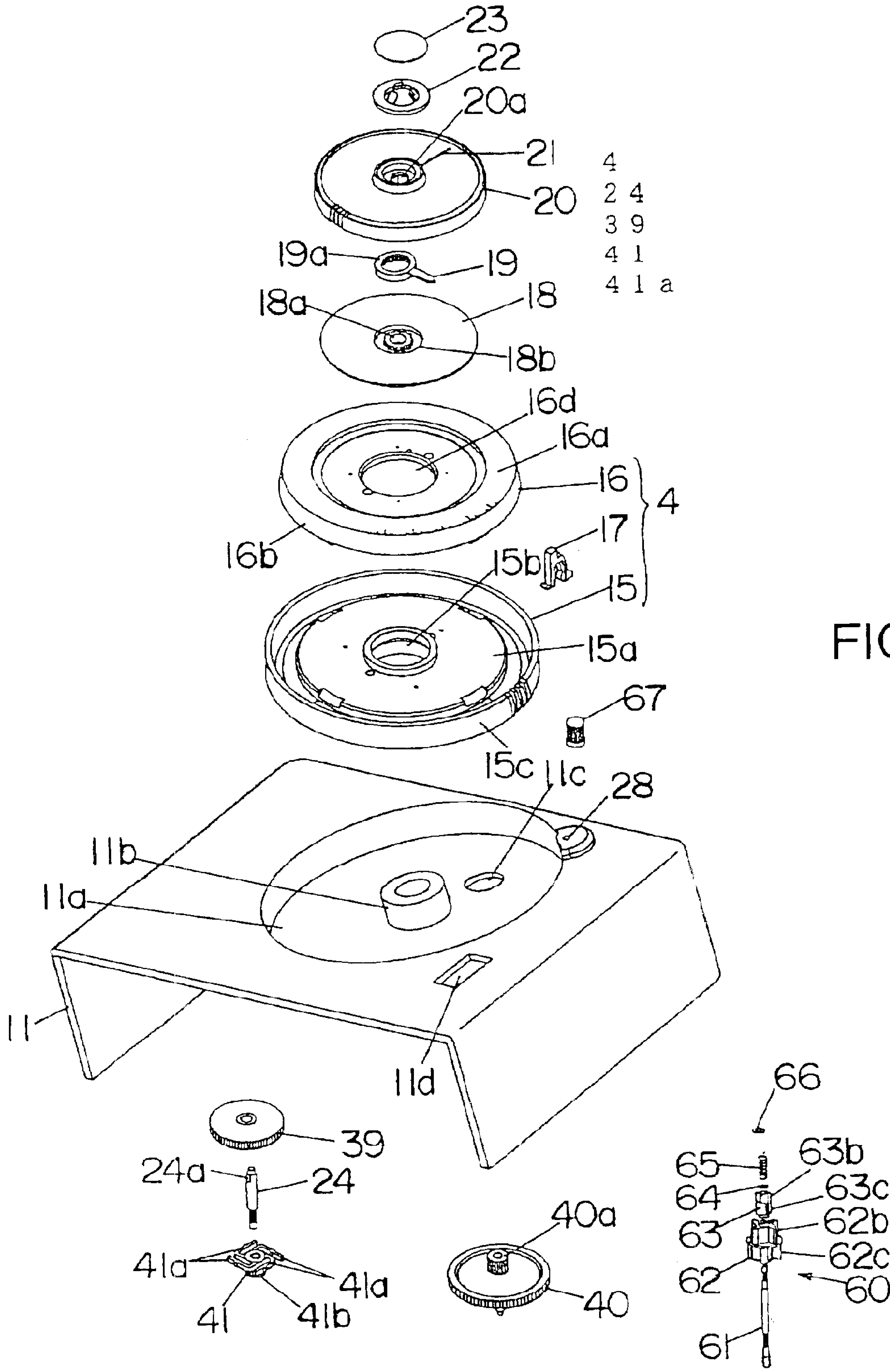
(57) **ABSTRACT**

A time switch that provides a convenient time setting method through a sub-dial that can be rotated clockwise or counter-clockwise. A gearwheel set, through which motor torque is conveyed to a dial, includes a ninth drive gear and a ninth shank gear which is joined to a step shaft on which the ninth drive gear rotates. A circular depression is formed within the rear side of the ninth drive gear, the inner perimeter on which are formed multiple ratchet teeth at uniform intervals. Ratchet pawls, which extend from the shank portion of the ninth shank gear, engage the ratchet teeth to form a ratchet mechanism that does not slip when the torque applied by the motor is sufficient to rotatably drive the dial, but that slips when the torque applied to the ratchet mechanism from the dial is greater than that applied by the motor.

11 Claims, 11 Drawing Sheets



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16b
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15b
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15a
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15c
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11b
11a
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11d
66
39
24a
24
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41b
40
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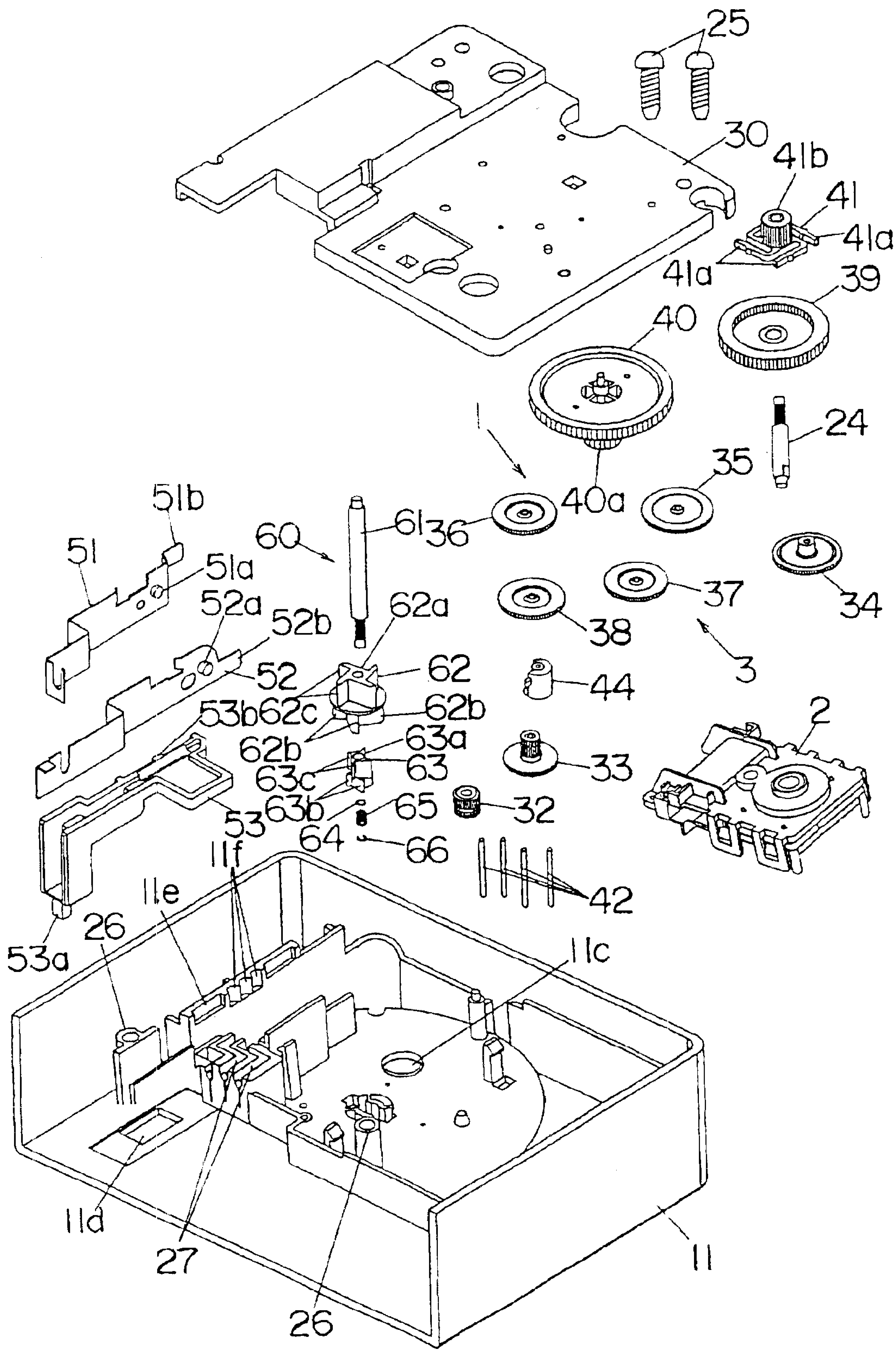
FIG.1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63c
63
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FIG.2

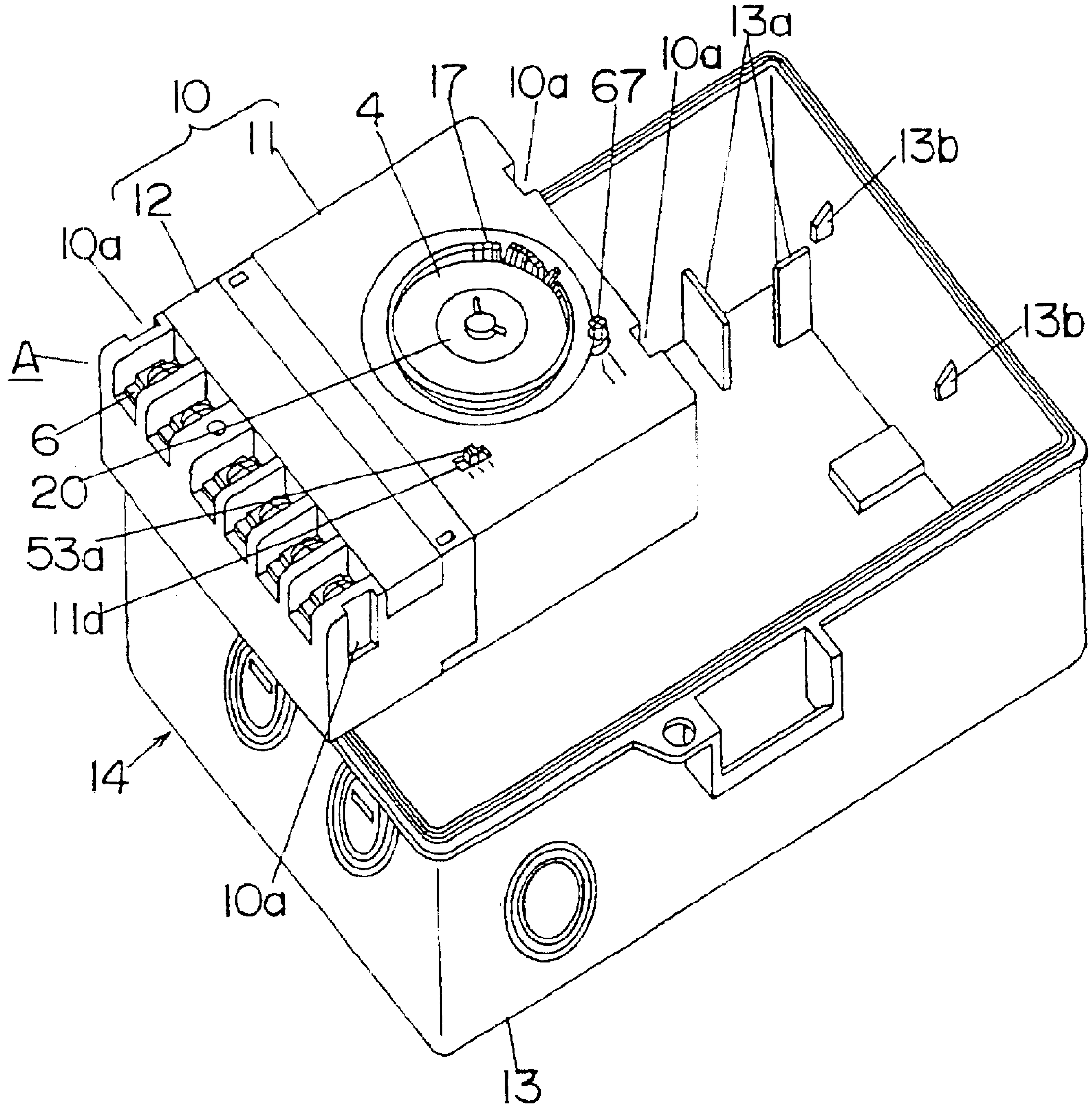
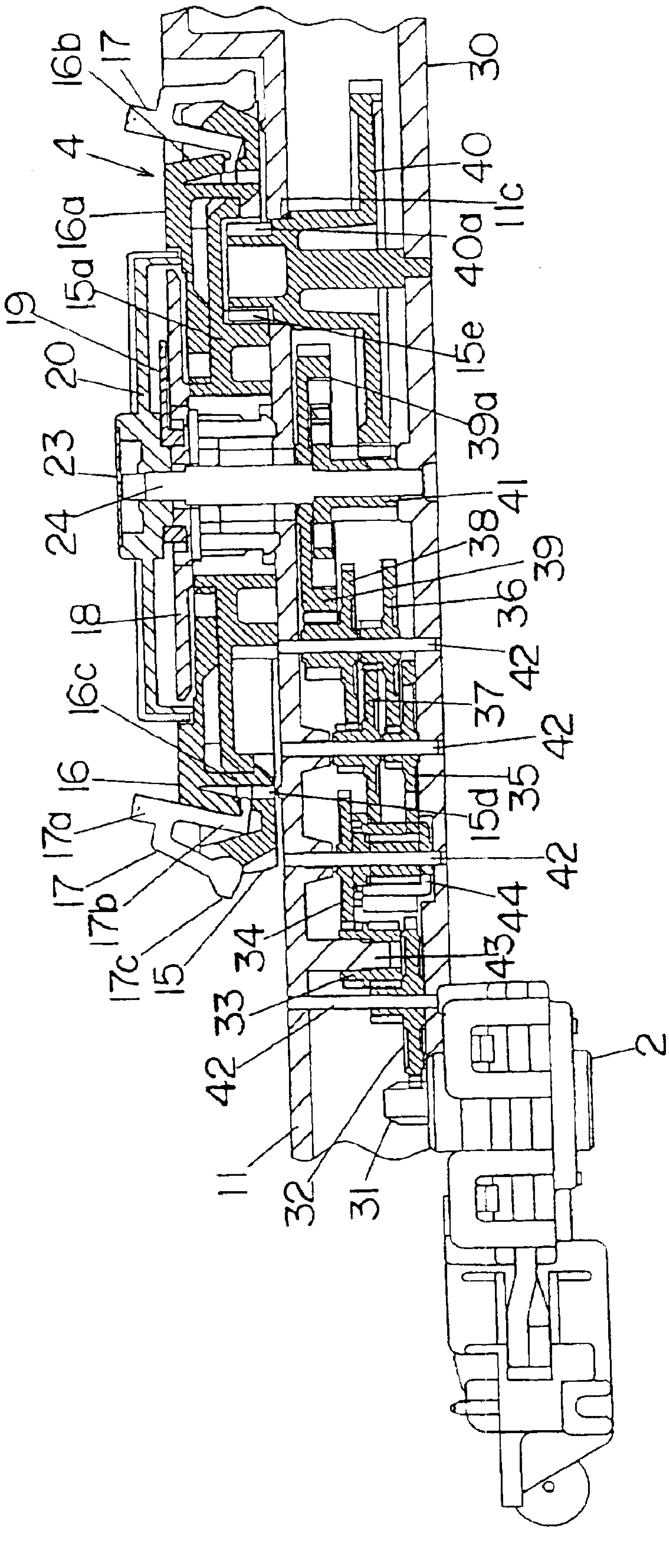


FIG.3



16b
17
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4
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16a
11c
40a
15a
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15e
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39a
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36
42
16c
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42
16
35
15d
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17b
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17c
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FIG.4

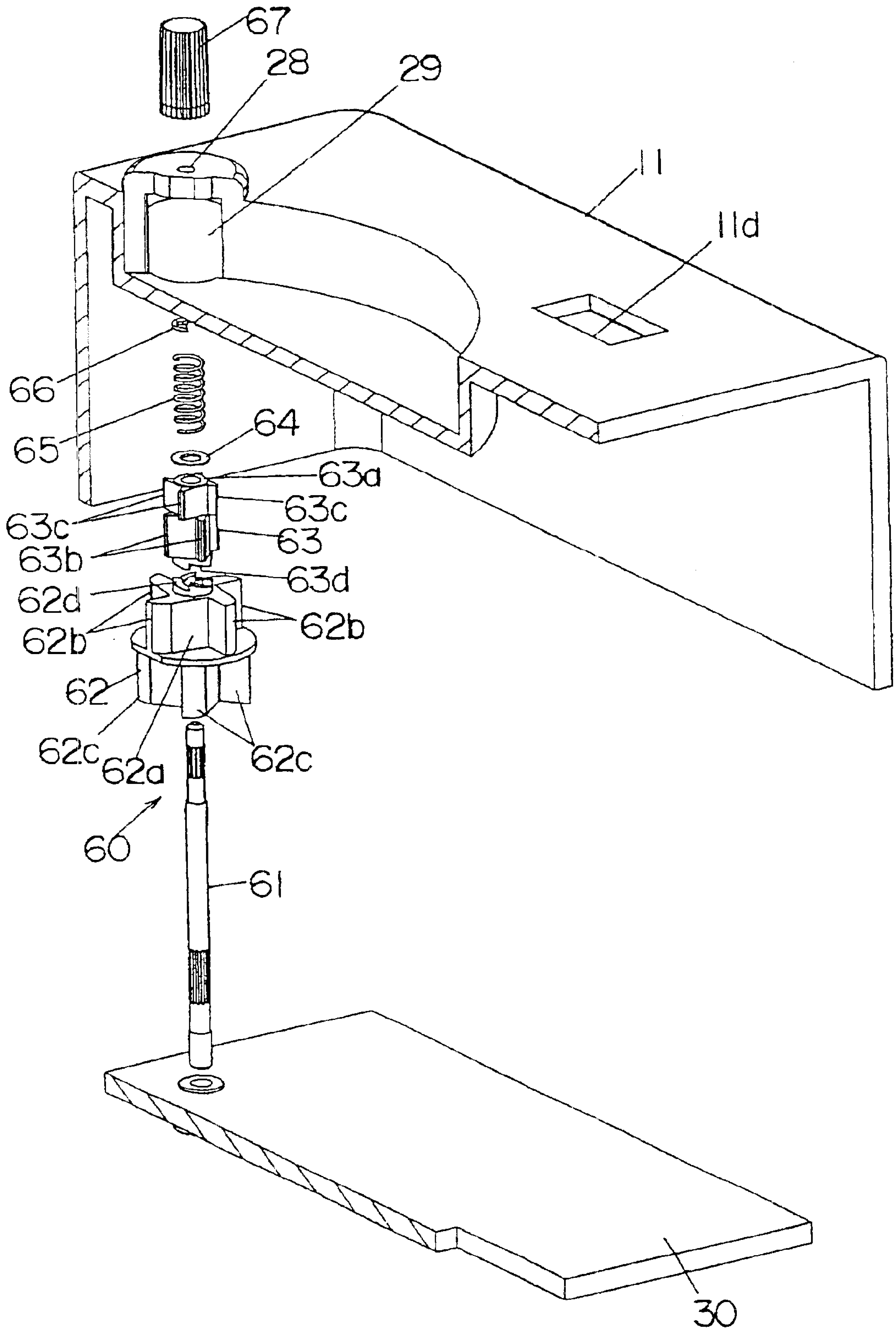
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FIG.5

FIG.6(a)

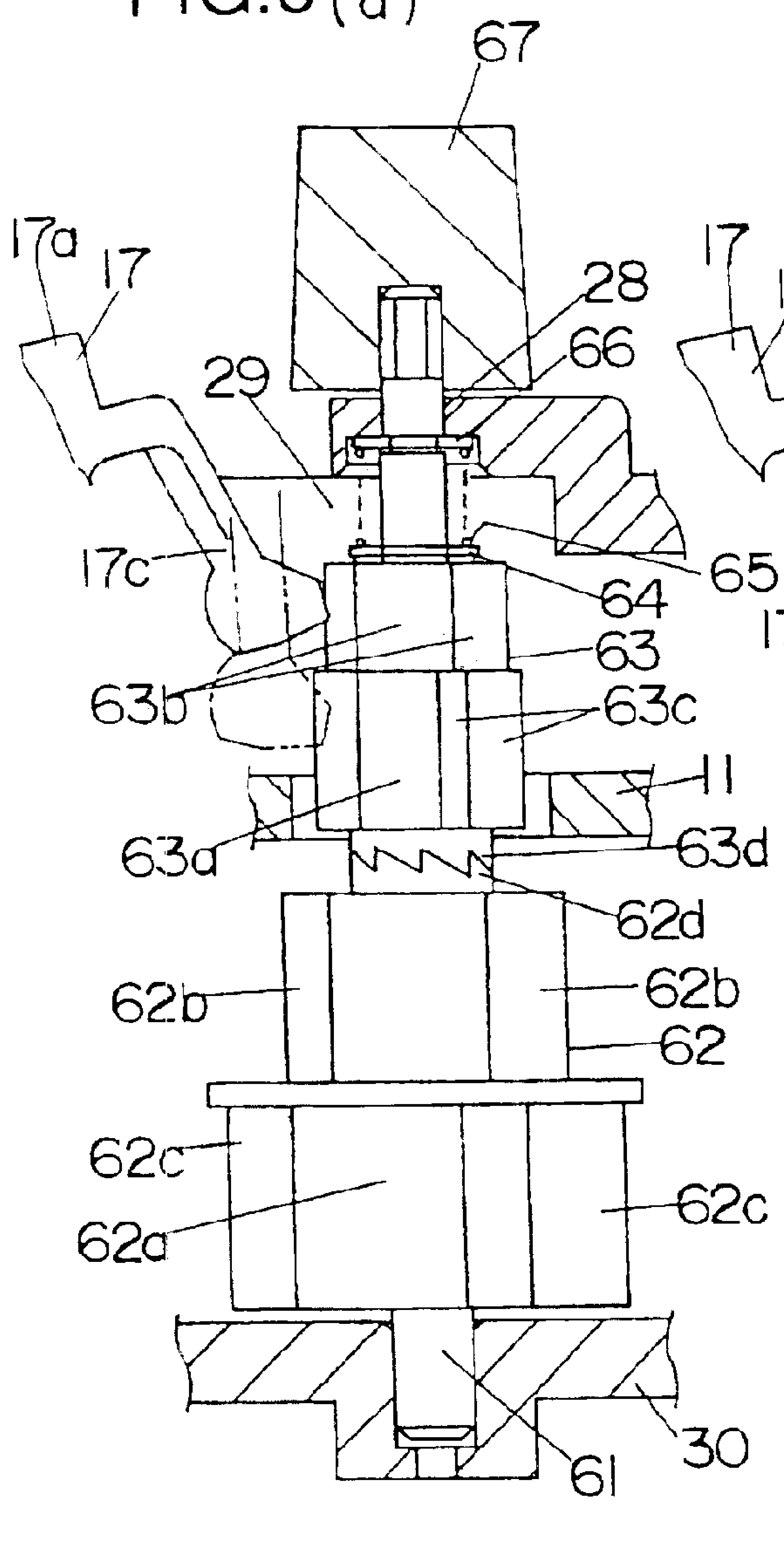
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FIG.6(b)

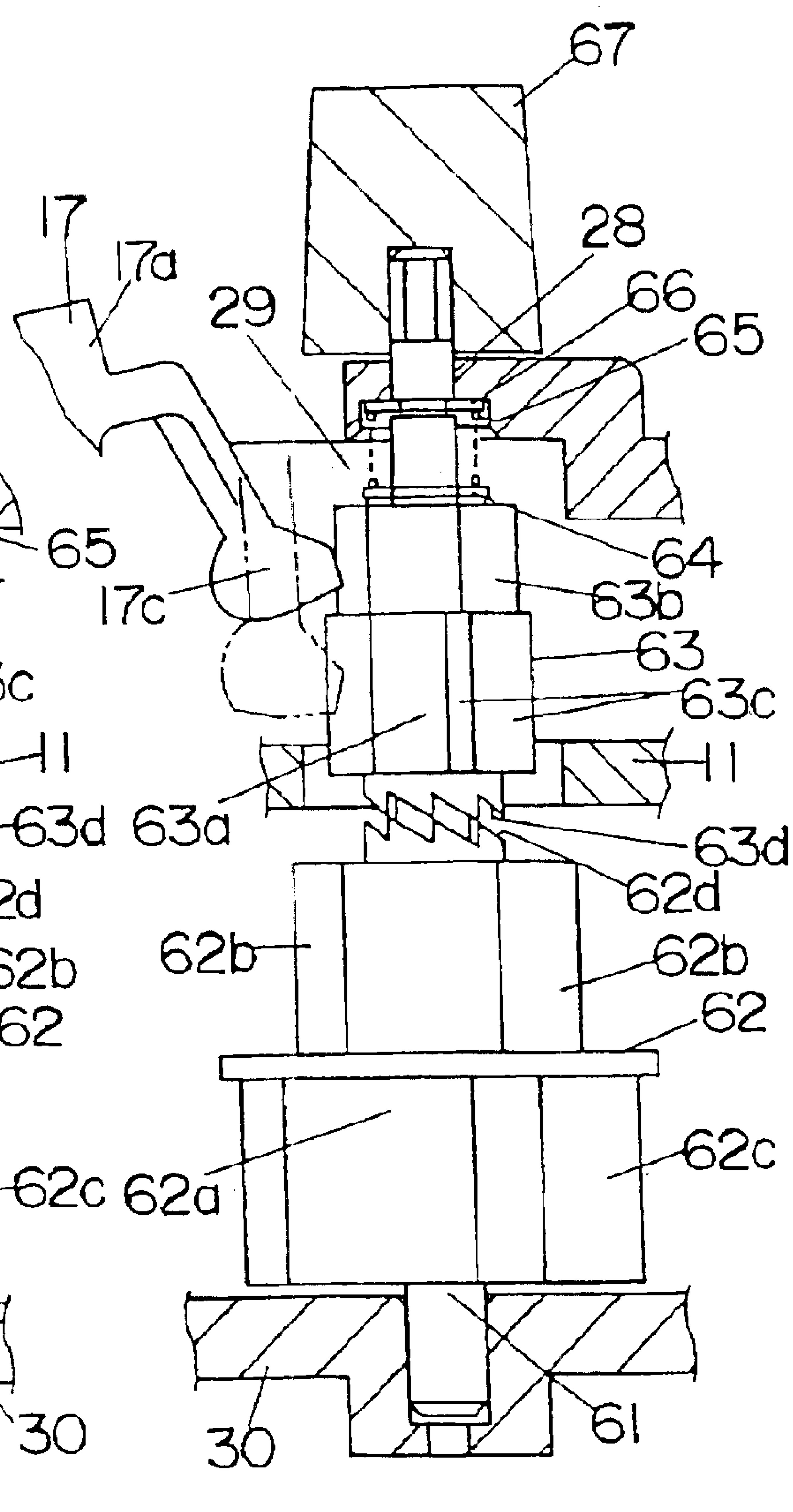
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FIG.7(a)

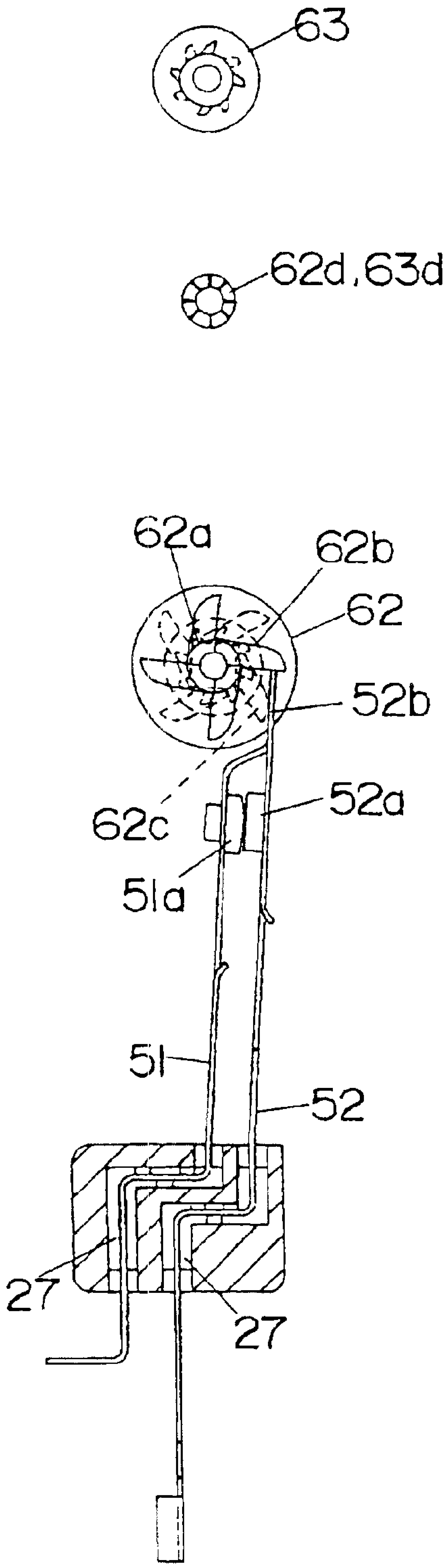
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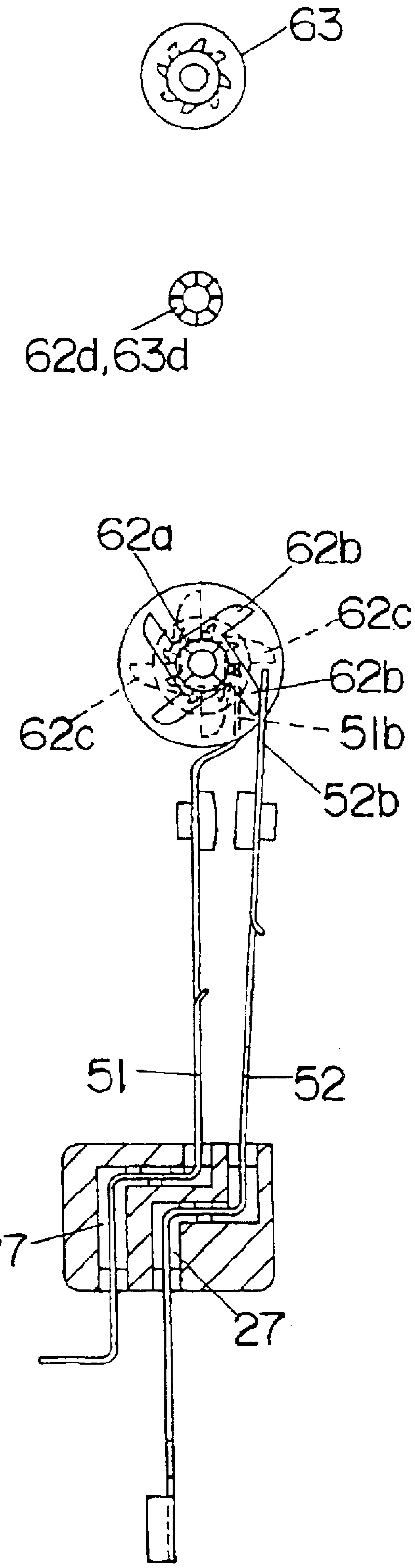
FIG.7(b)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62c
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FIG.8 (b)

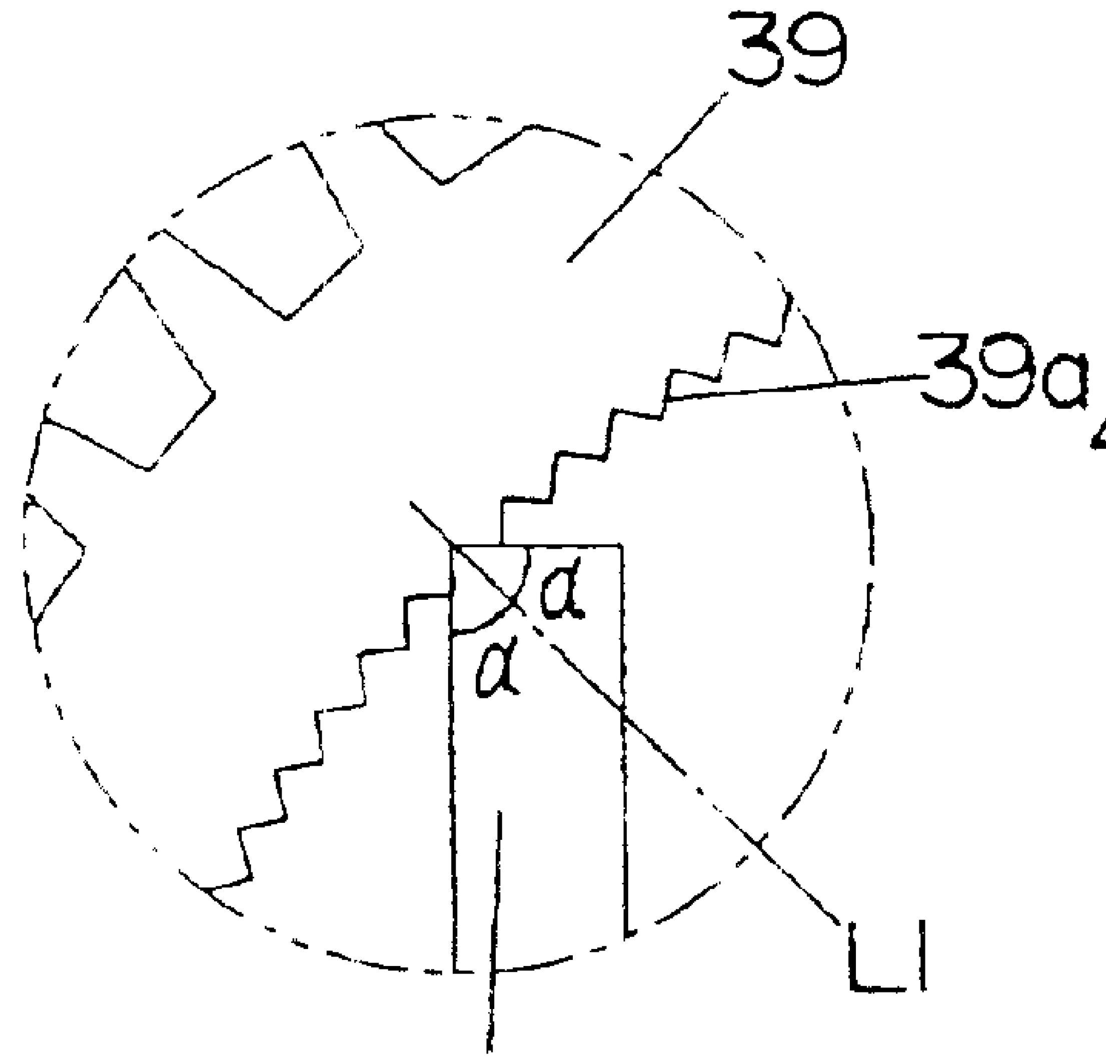


FIG.8 (a)

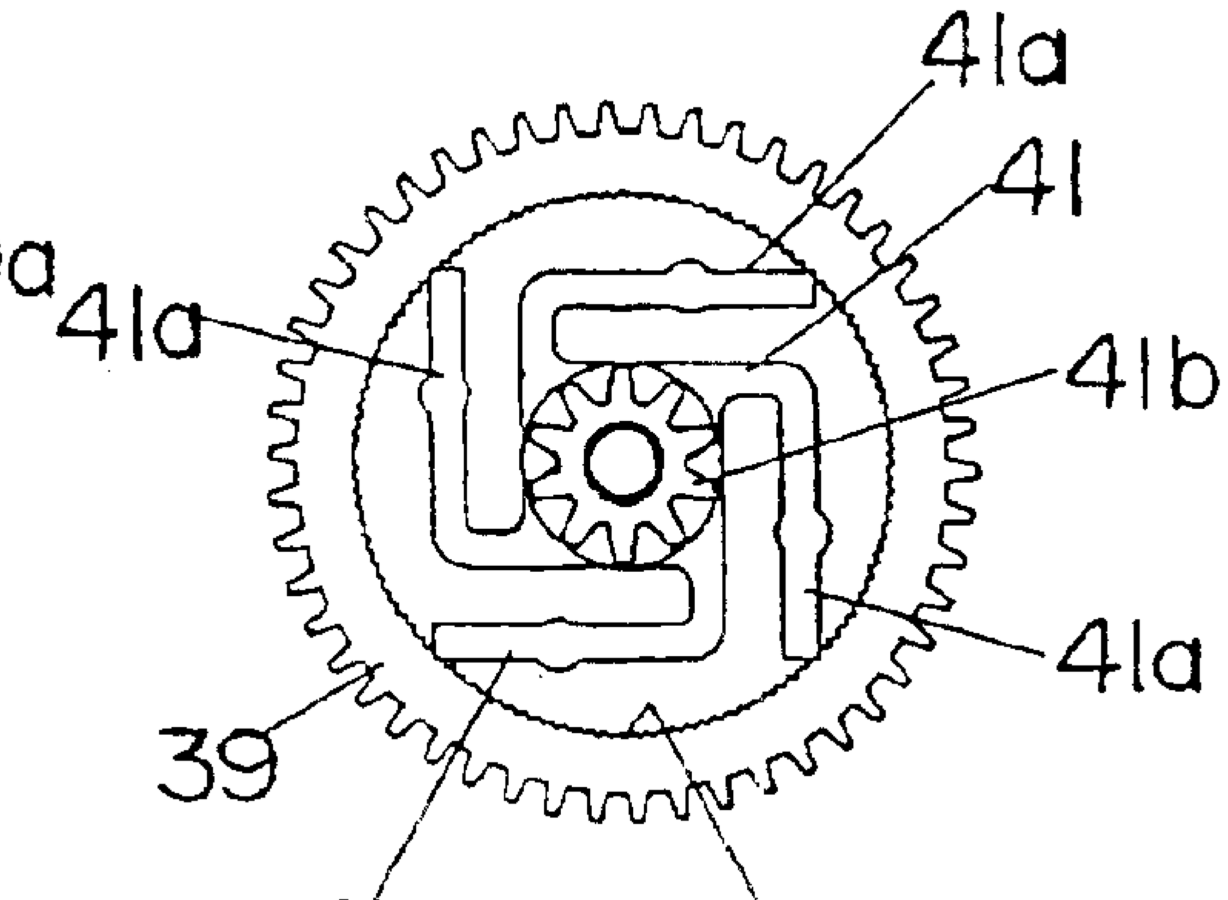


FIG.9 (b)

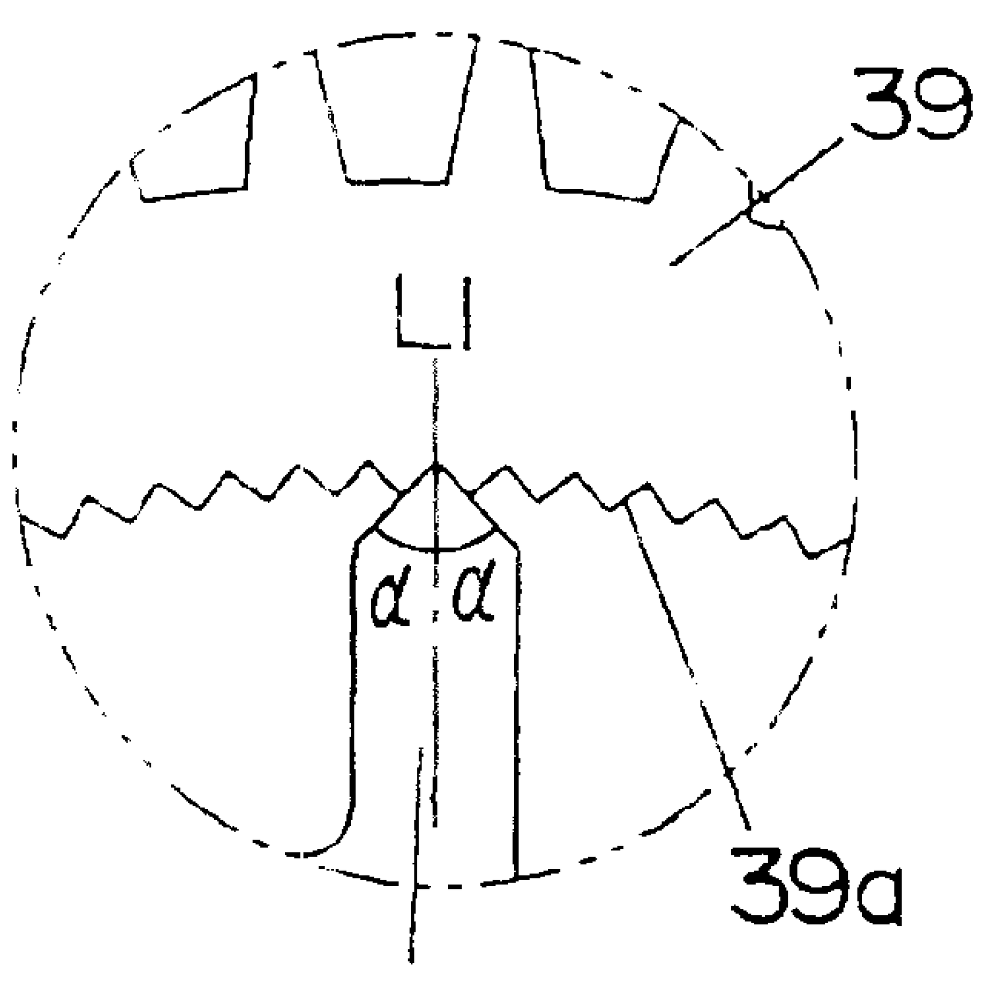


FIG.9 (a)

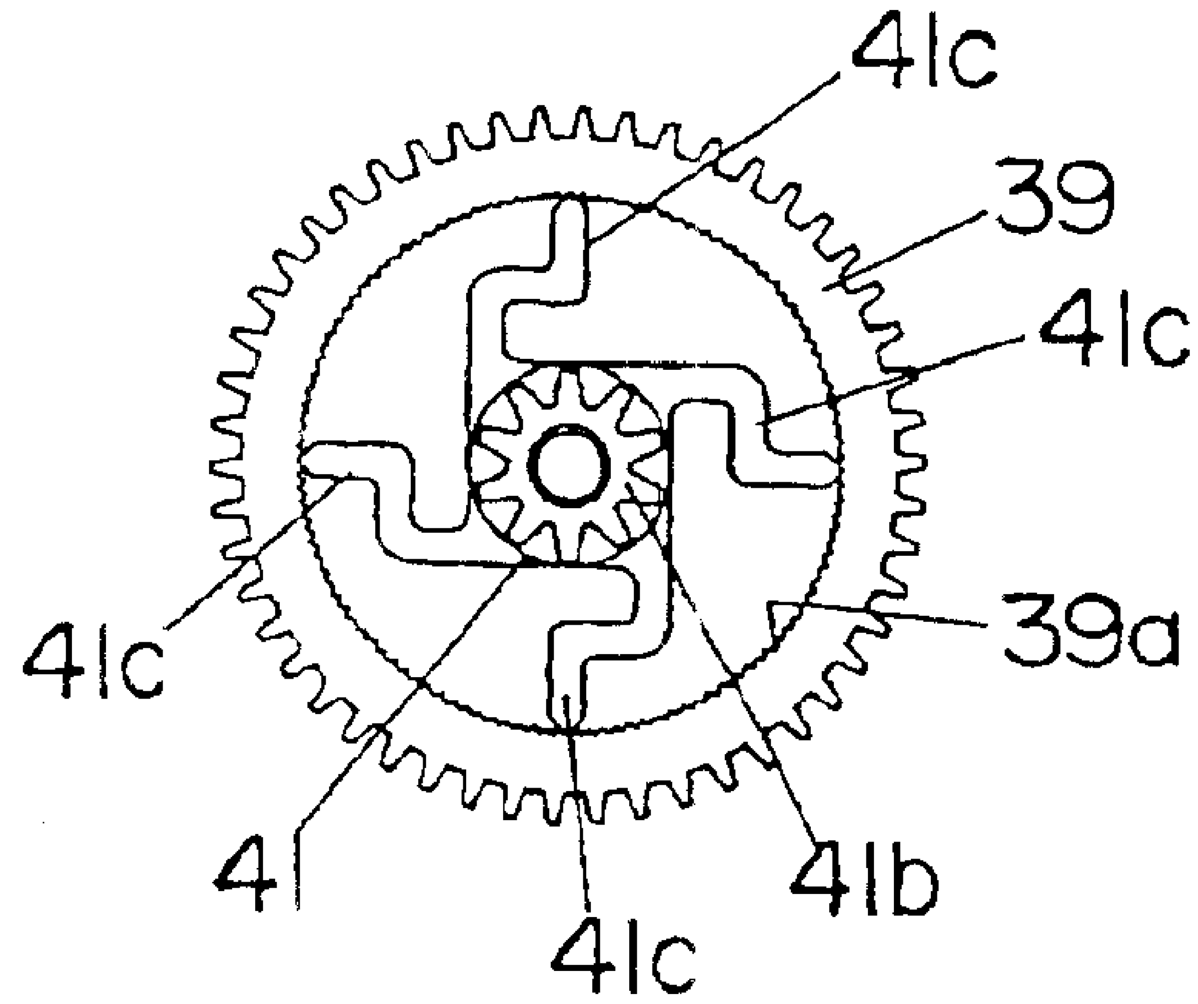


FIG.10 (b)

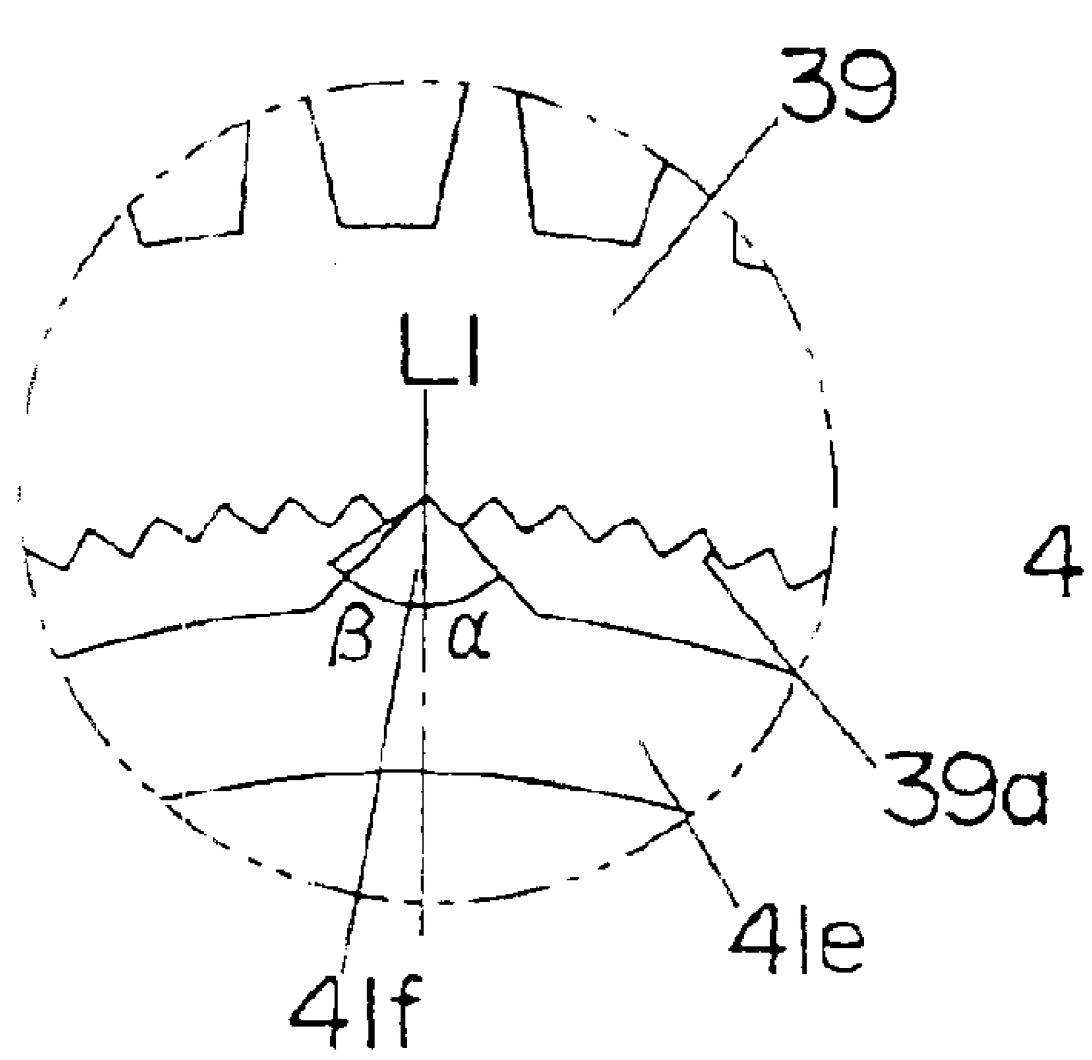


FIG.10 (a)

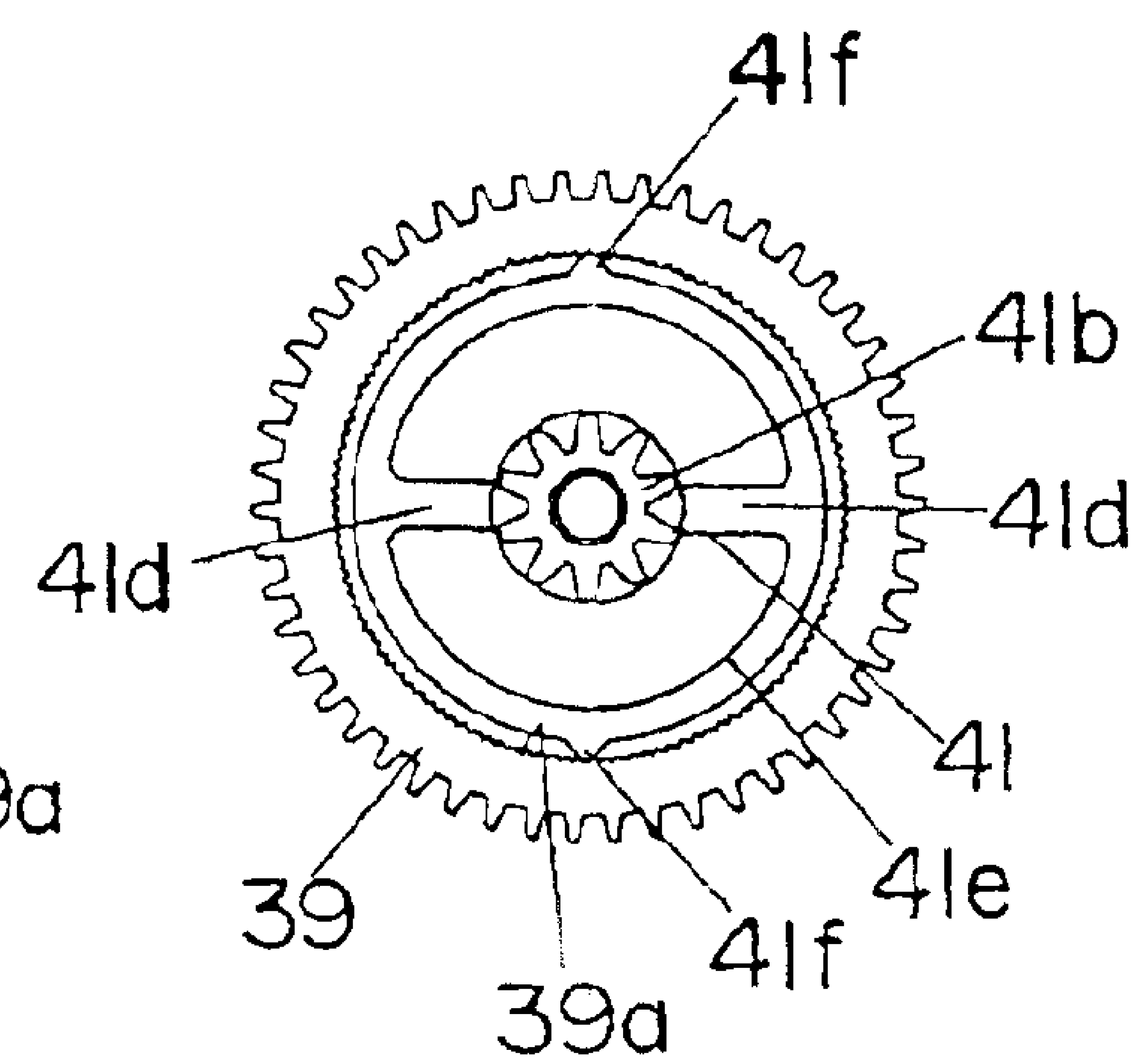


FIG.11

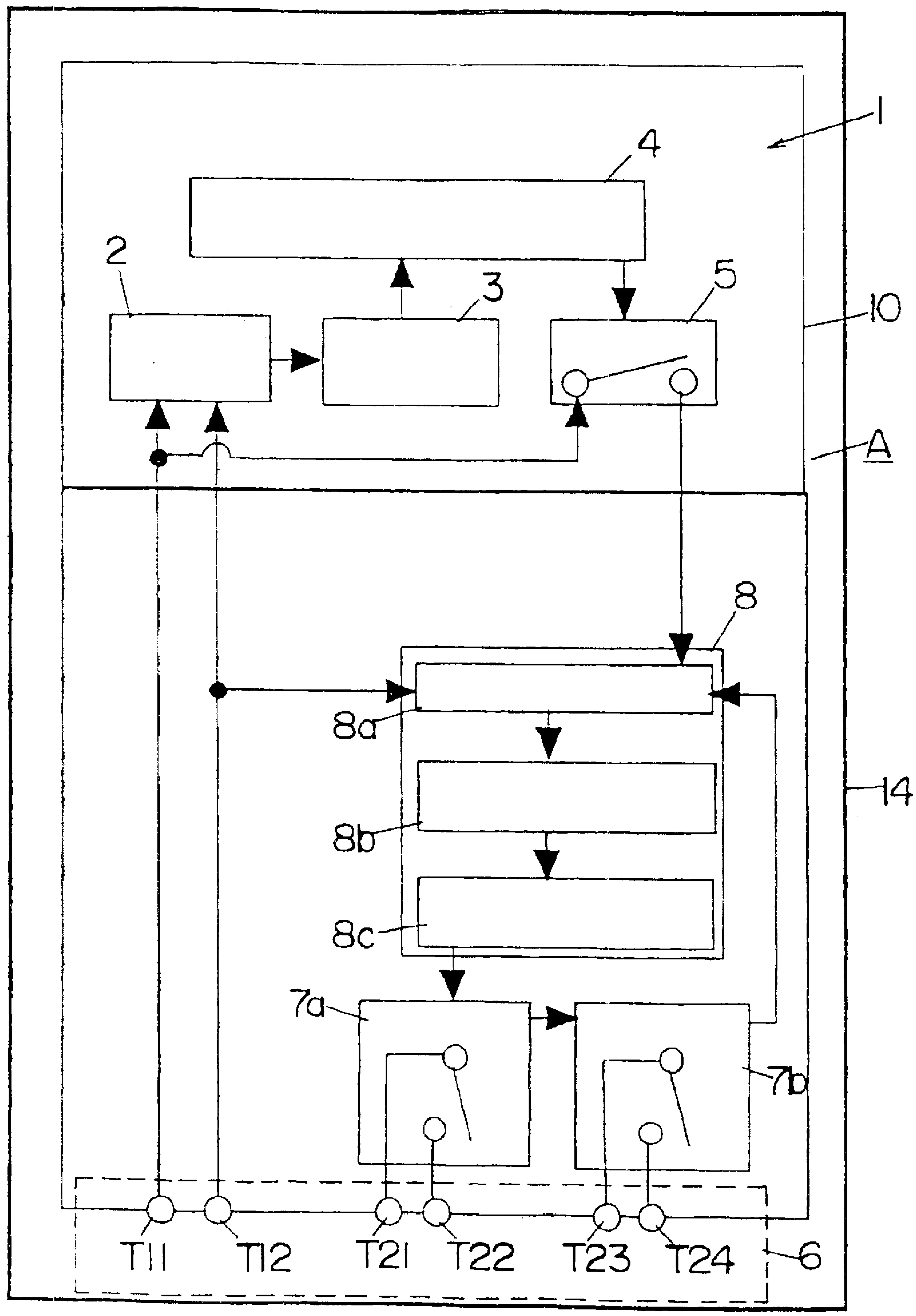


FIG.12

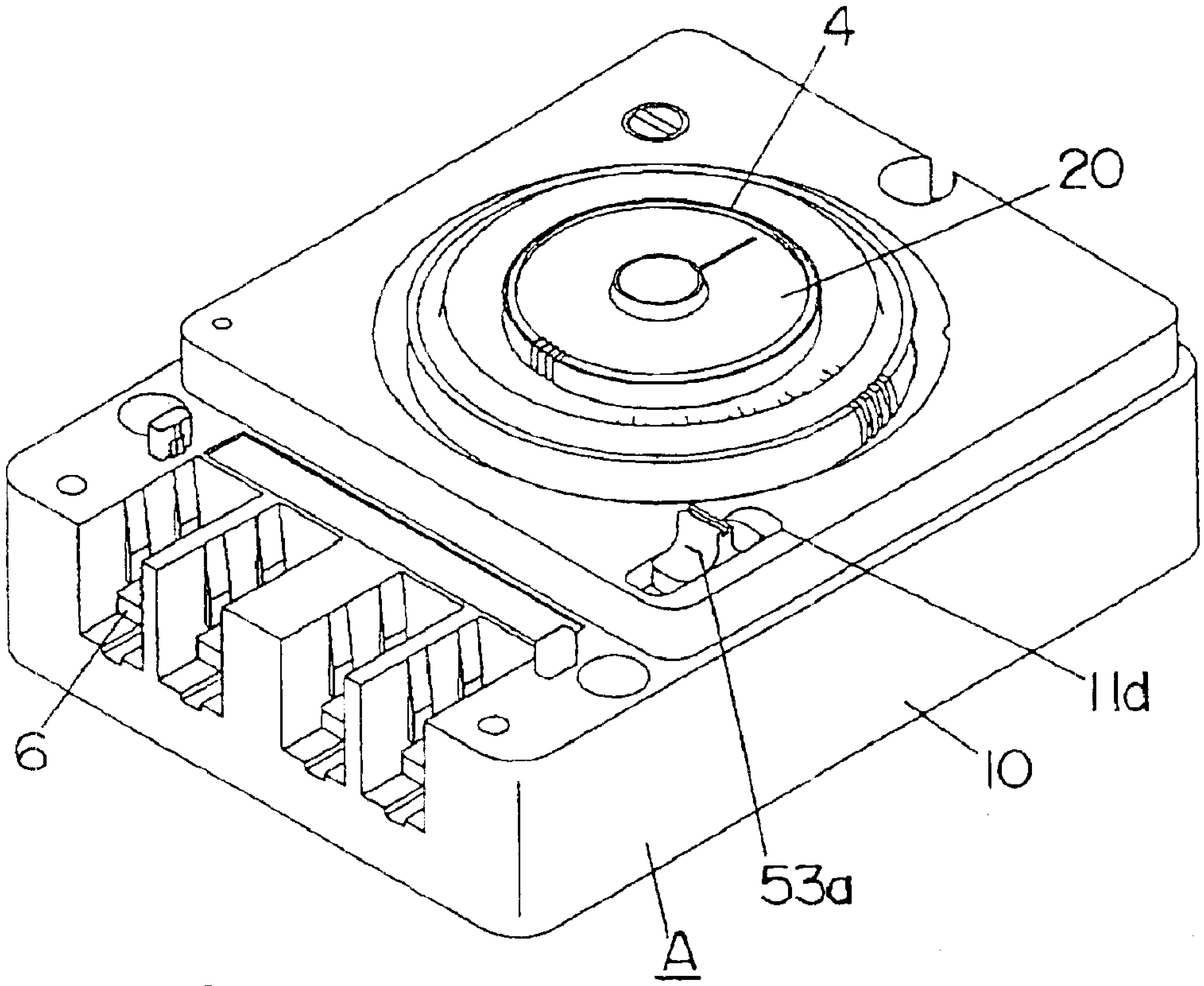
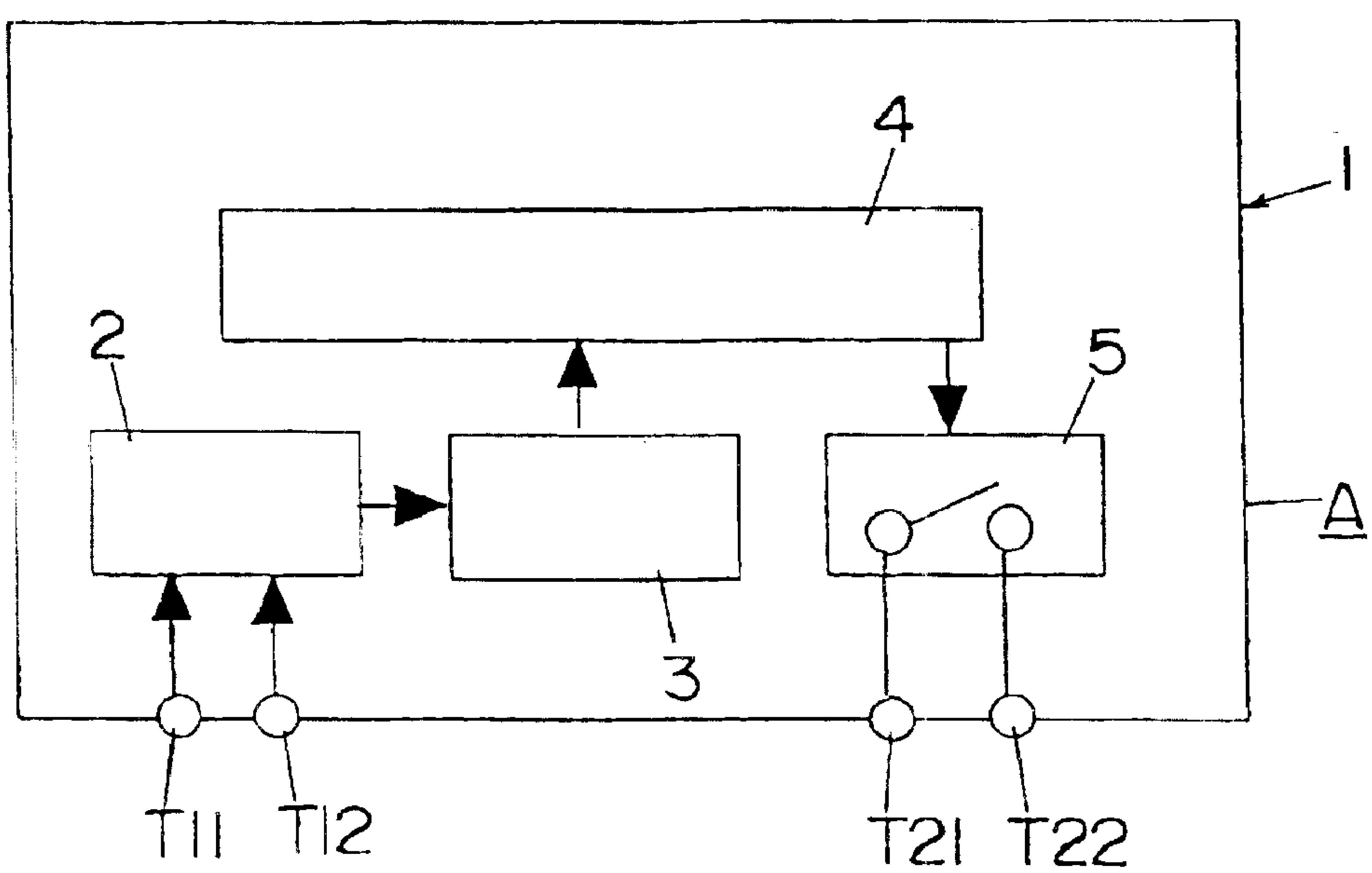


FIG.13



TIME SWITCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a time switch whereby the on and off states of internal contact points control the operation of an electrical load according to a time schedule.

2. Description of the Background Information

A conventional time switch, such as the type described in Japanese Kokai (laid open) Patent S63-29427, includes a modular structure assembled from a motor that rotates at a uniform speed, a ratchet gear driven by a gearwheel transmission powered by the motor, and a first gear that meshes with the ratchet gear. The time switch also includes a sub-dial that rotates clockwise at a rate of one revolution per hour relative to the rotation of the ratchet gear, a gear that meshes with a second gear attached to the rotating shaft of the sub-dial, a dial that rotates clockwise once during a 24-hour period relative to the rotation of the sub-dial, a scheduling clip with a finger that projects from the circumference of a dial used to set a desired operating time schedule, and an internal contact point activating mechanism that opens and closes the contact points through contact with a contact element that is freely settable to a desired time. In the time switch of Japanese Kokai (laid open) Patent S63-29427, the ratchet gear, which is rotatably driven by motor torque supplied through the gearwheel transmission, rotatably drives the sub-dial through the sub-dial shaft. Although the dial is rotationally driven by meshing with the second gear on the sub-dial shaft, the sub-dial shaft rotates only in one direction due to the ratchet mechanism formed by the first gear and ratchet gear at the rotating sub-dial shaft. As a result, even though the sub-dial can be turned manually to set the time, it can only be turned in one direction, thereby making it time-consuming to set the time. For example, when changing the time schedule due to the enactment of daylight savings time, it would be easy to turn the sub-dial back one hour from a current setting of 7 o'clock to a 6 o'clock setting. Because the sub-dial can only be turned in the clockwise direction, however, it must be advanced 23 hours to effect the desired time change. As a result, changing the time becomes a time-consuming operation.

SUMMARY OF THE INVENTION

In order to rectify the shortcomings of the prior art, the invention provides a time switch in which the time can be more conveniently set by turning the sub-dial in either a clockwise or counter clockwise direction.

An aspect of the present invention provides a time switch including a switch case, a dial rotatably attached to the face of the switch case, the dial rotatably driven at a uniform speed through a gearwheel transmission powered by a motor rotating at a uniform speed; scheduling clips including finger portions which project from the perimeter of the dial to determine a desired operating time; a cam shaft supported by the switch case; first cams projecting from the perimeter of a scheduling cam rotatably supported by the cam shaft, the scheduling cam rotatable through contact with respective finger portions of the scheduling clips, second cams projecting from the perimeter of a switching cam rotatably supported by the cam shaft, the switching cam rotatable in one direction together with the scheduling cam; contact points that switch between on and off positions relating to the rotation of the second cams provided on the switching cam; and a ratchet mechanism provided within the gearwheel mechanism that does not slip when torque transmitted from the motor is sufficient to rotatably drive the dial, and slips when the dial is manually turned while being rotatably driven by torque transmitted from the motor.

A further aspect of the present invention includes a manually rotatable sub-dial provided within the gearwheel transmission; wherein the ratchet mechanism is provided between the motor and the sub-dial. Further, the time switch may include a mechanism provided to generate greater resistance to rotation of the dial when the dial is manually turned in a direction counter to the direction in which it is turned by the motor. Further, the ratchet mechanism may include a disc-shaped member and multiple ratchet teeth formed at uniform intervals along the internal perimeter of a circular depression formed within one side of the disc-shaped member; a drive gear that rotates in response to rotation of the motor; a flexible ratchet pawl and a tip portion on the flexible ratchet pawl held in mesh with the ratchet teeth; and a shank gear that conveys torque from the drive gear to the dial; wherein the shank gear is rotatably driven by the drive gear, through the ratchet mechanism, by torque transmitted from the motor when the dial is rotatably driven by the motor, the torque being insufficient to disengage the ratchet mechanism, and wherein the shank gear disconnects from the drive gear due to the manual rotation of the dial conveying torque sufficient to flex the ratchet pawls to the extent of riding over the ratchet teeth.

A further aspect of the present invention provides a mechanism provided to generate a feeling of greater resistance when the dial is manually turned in a direction opposite to the motor-driven direction as compared to the feeling when the dial is manually turned in the motor-driven direction, the mechanism including a ratchet pawl tip symmetrically formed on both sides of the approximate radial intersection line at the inner perimeter of the circular depression; and triangular ratchet teeth having edges intersecting right and left sides of the radial intersecting line at different angles. The present invention may further include a clutch mechanism, the clutch mechanism including first clutch teeth formed on the side of the scheduling cam opposing the switching cam; second clutch teeth formed on the switching cam, the second clutch teeth meshing with the first clutch teeth; and a pressure applying device to apply pressure to the scheduling cam against the switching cam; wherein the first and second clutch teeth mutually engage to transfer torque from the scheduling cam to the switching cam when the dial is rotatably driven in the motor-driven direction, and wherein the first and second clutch teeth mutually disengage to prevent the transfer of torque from the scheduling cam to the switching cam when the dial is turned in a direction opposite to the motor-driven direction.

Further, wherein the number of the first and second clutch teeth includes as a whole integer multiple of the number of the first cams of the scheduling cam. Additionally, the pressure applying device may include a coil spring; the scheduling cam is rotatably supported by a cam shaft provided on the switching cam; the coil spring is positioned over the cam shaft to apply pressure to the scheduling cam against the switching cam; and a locking clip is joined to a groove formed in the cam shaft to support the coil spring between the scheduling cam and the lock ring. The time switch may include a friction reducing member provided between the scheduling cam and the coil spring. The shank gear may be formed integrally and in one piece with a supporting shaft. The cam shaft may be formed integrally and in one piece with the switching cam.

The present invention allows the time to be more conveniently set by manually turning the dial in either the motor-driven direction or the opposite direction thereto. This is made possible by the torque transmitted from the manually turned dial rotating the ratchet mechanism, thus preventing the transmission of torque from the motor to the dial.

Further, the manually rotatable sub-dial is installed within the gearwheel transmission, and the ratchet mechanism is installed between the motor and the sub-dial. This structure, allows the sub-dial to be manually turned in the motor-driven direction or the opposite direction thereto as means of more conveniently setting the time.

The mechanism able to generate greater resistance to the rotation of the dial when the dial is manually turned in a direction opposite to that in which it is turned by the motor and generates a stronger feeling of resistance when the dial is manually turned in a direction opposite to the motor-driven direction as compared to the resistance felt when the dial is manually turned in the motor-driven direction, therefore making it easy to discern, through the differently felt resistances, if the dial should be advanced or turned back.

In the ratchet mechanism, although torque transmitted from the dial will rotate the shank gear of the ratchet mechanism, the tips of the ratchet pawls will ride over the ratchet teeth causing the shank gear to disengage from the drive gear, thus allowing the time to be more conveniently set through the manual rotation of the dial in either the motor-driven direction or the opposite direction thereto.

By including triangular ratchet teeth whose edges intersect the right and left sides of the radial intersection line at different angles, the ratchet teeth may be easily designed to a configuration that generates more resistance when the ratchet pawls ride over the ratchet teeth when the dial is turned in a direction opposite to the motor-driven direction than when the ratchet pawls ride over the ratchet teeth when the dial is turned in the same direction as that driven by the motor. This structure thus makes it easy to establish a stronger feeling of resistance when the dial is turned back to the desired time setting than when advanced to that time setting.

When the dial is turned in a direction opposite to the motor-driven direction, the scheduling cam rotates as a result of the clip finger of the scheduling clip (which projects from the perimeter of the dial) pressing against the first cam. However, the rotation of the scheduling cam is not conveyed to the switching cam because the clutch mechanism mutually disengages the first and second clutch teeth. This mechanism prevents the switching cam from rotating in a direction opposite to the motor-driven direction, and thus prevents the unnecessary operation of the contact points as would otherwise occur if the switching cam were to rotate in a direction opposite to the motor-driven direction.

As a result of the disengagement of the first and second ratchet teeth, only the scheduling cam will rotate when the dial is turned in a direction opposite to the motor-driven direction. However, by establishing the number of first and second clutch teeth as a whole integer multiple of the number of first cams on the scheduling cam, the first clutch teeth on the scheduling cam will engage the second clutch teeth on the switching cam as soon as the scheduling cam completes its rotation. Thus, a mechanism is provided through which the switching cam will be immediately driven by the scheduling cam when the dial rotates in the motor-driven direction.

By rotatably installing the scheduling cam over a cam shaft integrally formed with the switching cam, placing the coil spring over the cam shaft, and attaching the lock clip to the cam shaft, a block-type clutch assembly is formed which can be easily assembled to the switch case.

Because a large amount of friction would be generated between the scheduling cam and coil spring if the coil spring were in direct contact with the rotating scheduling cam, the provision of a friction-reducing member between the scheduling cam and coil spring results in the smooth rotation of the scheduling cam.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, and other objects, features and advantages of the present invention will be made apparent from the following description of the preferred embodiments, given as nonlimiting examples, with reference to the accompanying drawings in which:

FIG. **1** is an exploded partial perspective view, as seen when viewed from above the clock mechanism, of the time switch of a first embodiment of the present invention;

FIG. **2** is an exploded partial perspective view, as seen when viewed from below the clock mechanism, of the time switch of the embodiment of FIG. **1**;

FIG. **3** is a perspective view of the time switch of the embodiment of FIG. **1** with external an case;

FIG. **4** is a cross sectional view of the gearwheel transmission of the time switch of the embodiment of FIG. **1**;

FIG. **5** is an exploded perspective view of the switch cam assembly of the time switch of the embodiment of FIG. **1**;

FIG. **6***a* is a cross sectional view switch assembly of the time switch of the embodiment of FIG. **1**;

FIG. **6***b* is a cross sectional view of the switch assembly of the time switch of the embodiment of FIG. **1**;

FIG. **7***a* shows the operation of the contact points of the time switch of the embodiment of FIG. **1**;

FIG. **7***b* shows the operation of the contact points of the time switch of the embodiment of FIG. **1**;

FIG. **8***a* shows the ninth shank gear housed within the ninth gear of the time switch of the embodiment of FIG. **1**, as viewed from below;

FIG. **8***b* shows the ninth shank gear housed within the ninth gear of the time switch of the embodiment of FIG. **1** at their point of mutual contact;

FIG. **9***a* shows a variation of the ninth shank gear housed within the ninth gear of the time switch of the embodiment of FIG. **1**, as viewed from below;

FIG. **9***b* shows an exploded view of the ninth shank gear of FIG. **9***a* housed within the ninth gear at their point of mutual contact;

FIG. **10***a* shows a variation of the ninth shank gear housed within the ninth drive gear of the time switch of the embodiment of FIG. **1** as viewed from below;

FIG. **10***b* shows an exploded view of the ninth shank gear of FIG. **10***a* housed within the ninth drive gear of the time switch of the embodiment of FIG. **1** at their point of mutual contact;

FIG. **11** is a block diagram of the time switch of the embodiment of FIG. **1**;

FIG. **12** is an external perspective view of a second embodiment of the time switch of the present invention; and

FIG. **13** is a block diagram of the time switch of the embodiment of FIG. **12**.

DETAILED DESCRIPTION OF THE INVENTION

The particulars shown herein are by way of example and for purposes of illustrative discussion of the embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the present invention. In this regard, no attempt is made to show structural details of the present invention in more detail than is necessary for the fundamental understanding of the present invention, the description is taken with the drawings making apparent to those skilled in the art how the forms of the present invention may be embodied in practice.

The following will describe embodiments of the invention with reference to the accompanying drawings. The first embodiment of the present invention will be described with reference to FIGS. **1** through **11** with positional references (top, bottom, right, left) being based on FIG. **3** unless otherwise specified.

As shown in FIG. **3**, switch case **10** of time switch 'A' is formed as an assembly of main case **11** and sub-case **12**, main case **11** housing mechanical clock mechanism **1**, and sub-case **12** housing externally exposed screw-type input-output terminal portion **6** and internally located relay drive circuit **8** (to be described subsequently) that drives relays **7***a* and **7***b*. Switch case **10** of time switch 'A' is housed within outer case **14** which includes box-shaped lower case **13**, of which the top portion is open, and an upper case (not shown in the drawing) that covers the open top portion of lower case **13**. Switch case **10** is placed on the floor of lower case **13**, and is secured in position by multiple projecting ribs **13***a*, notches **10***a* which are formed on at least three sides of switch case **10**, tabs **13***b* that extend inward from the sidewalls of lower case **13** into notches **10***a*, and lock fingers (not shown) formed on the floor of lower case **13**, the tips of the lock fingers being formed as hook parts that join to notches **10***a*. Switch case **10** is placed over ribs **13***a*, and tabs **13***b* connect to notches **10***a* and the hook parts, thus securely attaching switch case **10** to the floor of lower case **13**. Alternatively, switch case **10** may be secured to outer case **14** through the use of any suitable devices such as, for example, screws or other such mounting hardware.

Time switch 'A' is equipped with the electrical circuit shown in FIG. **11**. Clock mechanism **1**, which is installed in main case **11**, is equipped with synchronous motor **2** that rotates at a uniform speed of 600 rpm synchronized with the frequency of commercially supplied electrical power. Alternatively, instead of the synchronous motor **2**, the present invention may include any suitable motor such as, for example, a stepping motor controlled by the output of a crystal-driven oscillating circuit.

Gearwheel transmission **3** reduces the speed of synchronous motor **2** at a ratio of 864,000/1 to drive dial **4**, which is located at the center of the front surface of main case **11**, at a rate of 1/1,440 rpm. In other words, dial **4** rotates once every 24 hours for the 24-hour time switch described in this embodiment. Therefore, setting the desired time schedule through the placement of scheduling clip **17** on dial **4** will result in contact points **5** opening and closing, according to the time schedule, in order to generate operating signals.

Input-output terminal portion **6**, which is provided on sub case **12**, is equipped with a pair of electric power terminals T11 and T12 that connect to a commercial electricity power source. This embodiment also includes two pairs of load terminals, T21 and T22, and T23 and T24, which are able to control two electrical loads. Load terminals T21 and T22, and load terminals T23 and T24 are controlled by the operation of contact points within load control relays **7***a* and **7***b* respectively, the contact points being opened and closed through the operation of relay drive circuit **8**. Relay drive circuit **8** is made up of AC voltage drop circuit **8***a* which acts as a transformer to drop the source voltage, rectification circuit **8***b* which rectifies the output of AC voltage drop circuit **8***a* to output a DC voltage, and relay voltage circuit **8***c* which lowers and smooths the DC voltage from rectification circuit **8***b* so that relays **7***a* and **7***b* receive the required voltage. One input terminal of relay drive circuit **8** is connected to power terminal T11 through contact points **5**, and the other input terminal is connected to power terminal T12. Therefore, when contact points **5** go "on" according to the set time schedule, electrical power is supplied to activate relays **7***a* and **7***b*.

The following will describe the structure of clock mechanism **1** with reference to the accompanying drawings. FIG. **2** shows an exploded perspective view of the components including clock mechanism **1** which is installed within main case **11**. Clock mechanism **1** is made up of multiple gears **32** through **41**, gear shafts **42**, spring arms **51** and **52** to which contact points **51***a* and **52***a* are attached, switch bracket **53** which is used to select the operating mode, cam switch assembly **60** which is used to manually connect or separate the contact points and, as will be described subsequently, to connect or separate the contact points according to the time schedule set by scheduling clip **17**, the components being installed and aligned in parallel with the front wall of main case **11** between center cover **30** and main case **11**. Moreover, while center cover **30** is attached to main case **11** by screws **25** inserted through holes in center cover **30** and into threaded bores provided in bosses **26** located on the rear surface of main case **11**, center cover **30** may also be attached to main case **11** through any suitable device such as, for example, interlocking members.

The following will describe gearwheel transmission **3** with reference to FIGS. **2** and **4**. Synchronous motor **2**, including the output shaft, is installed on the rear surface of center cover **30**, and first shank gear **31** meshes with second gear **32** through a hole provided in mid-cover **30**. Gears **32** through **38** are rotatably supported on gear shafts **42** located between main case **11** and mid-cover **30**, and on gear shaft **43** that extends from the rear surface of main case **11**. Ninth drive gear **39** is rotatably supported by step shaft **24**. A circular recess is formed within the rear side of ninth drive gear **39**, and ratchet teeth **39***a* are formed on the inner circumference of the circular recess in the form of multiple uniformly spaced triangular teeth (see FIG. **8***a*). Moreover, ninth shank gear **41** is fixedly attached to step shaft **24** through interference fitting, gluing, welding, or other desired attachment method so that gear **41** rotates together with step shaft **24** (on which ninth drive gear **39** freely rotates) as a single structure. L-shaped pawls **41***a*, which extend at uniform intervals from the perimeter of the shank part of ninth shank gear **41** in a configuration of angled spokes, mesh with multiple ratchet teeth **39***a*. The flanks of ratchet teeth **39***a* and the tips of pawls **41***a* are formed to approximately the same angle α (e.g. 45 degrees) with respect to line L1 that radially intersects the inner circumference of the recessed part of ninth drive gear **39**. A ratchet mechanism is formed by the tips of pawls **41***a* contacting ratchet teeth **39***a* while pinion gear **41***b* of ninth shank gear **41** meshes with mushroom gear **40**. Moreover, pawl **41***a* is structured as a finger-like member whose tip part meshes with ratchet teeth **39***a*. Circular recessed part **11***a*, which is formed within the front part of main case **11** in order to house dial **4**, incorporates through hole **11***c* in the bottom part into which gear **40***a* of mushroom gear **40** is inserted. Gear **40***a*, which projects to the front side of through hole **11***c* and meshes with gear **15***e* of dial base **15**, will be described subsequently.

With gearwheel transmission **3** thus structured, the rotational torque of first shank gear **31**, which is attached to and rotatably driven by the output shaft of motor **2**, is transferred to ninth drive gear **39** through second gear **32**, third gear **33**, fourth gear **34**, fifth gear **35**, sixth gear **36**, seventh gear **37**, and eighth gear **38**. Therefore, ninth drive gear **39** rotates in the same direction as the motor, and because the tooth flanks of ratchet teeth **39***a* of ninth drive gear **39** press against the tips of pawls **41***a* of gear **41**, ninth shank gear **41** is rotatably driven in the same direction as ninth drive gear **39**, and the rotation of ninth shank gear **41** is transferred to sub-dial **20** through step shaft **24**. Also, torque is transferred to dial **4** through mushroom gear **40** which drives sub-dial **20** and dial **4** in a clockwise direction. As synchronous motor **2** rotates at a speed synchronized to the frequency of commercial electric power, gearwheel transmission **3** reduces the speed of the motor to a point where sub-dial **20** rotates once per hour, and dial **4** rotates once in 24 hours. Moreover, rotational restrictor cam **44**, which is installed at fourth gear **34**, restricts the direction that sub-dial **20** and dial **4** may be rotated by driven motor **2** to only a clockwise direction. Although the rotational direction of fifth gear **35** is restricted, rotational restrictor cam **44** would not be needed if motor **2** were the type that rotates in only one direction.

The following will describe contact points **5** and cam switch assembly **60** with reference to FIGS. **2**, **5**, **6**, and **7**. As shown in FIG. **1**, spring arms **51** and **52** are rectangular metal members into which an S-shaped portion is bend-formed at the mid-point, and each S-shaped portion is secured within main case **11** by being pressed into channel **27** formed therein. Mutually opposing contact points **51***a* and **52***a* are formed on the free ends of spring arms **51** and **52**. Flange **51***b* extends from the lower part of the end of spring arm **51** (the side of spring arm **51** opposite to the front wall of main case **11**) as the part of spring arm **51** that contacts lower cams **62***c* of switching cam **62**, described below. Flange **52***b* extends from the upper part of the end of spring arm **52** as the part of spring arm **52** that contacts an upper cam **62***b* of switching cam **62**.

Switch bracket **53**, which may be formed from any suitable material such as, for example, molded from synthetic resin, includes lug **53***a* that is inserted into window orifice **11***d* in main case **11** with switch bracket **53** provided within slide channel **11***e*, thus allowing switch bracket **53** to slide within the limits of window orifice **11***d* to any of three positions located by ridge **53***b* inserted into one of three channels **11***f* formed on main case **11**. In other words, lug **53***a* can be switched between three positions. With lug **53***a* placed at the middle "automatic" position, the motor-driven or manual rotation of dial **4** results in the rotation of switching cam **62** of cam switch assembly **60**, described below, and the bendable closing or opening of contact points **51***a* and **52***a* on spring arms **51** and **52** (automatic mode). Sliding lug **53***a* to the "off" position, a position where switch bracket **53** is at one end of its traversable limit, results in a projection on switch bracket **53** pushing spring arm **51** away from spring arm **52**, thus separating contact points **51***a* and **52***a* (an "off" condition) and rendering them unaffected by the operation of scheduling clip **17** (which projects from the perimeter of dial **4**) and cam switch assembly **60**. Also, sliding lug **53***a* to the "on" position, the position where switch bracket **53** is at the other end of its traversable limit, results in a projection on switch bracket **53** pushing spring arm **52** toward spring arm **51**, thus connecting contact points **51***a* and **52***a* (an "on" condition) and rendering them unaffected by the operation of clip **17** (which projects from the perimeter of dial **4**) and cam switch assembly **60**. "Off," "Auto," and "On" markings are provided on the front of main case **11** to easily identify the position of lug **53***a*.

Further, cam switch assembly **60** includes cam shaft **61**, switching cam **62**, scheduling cam **63**, thrust washer **64**, coil spring **65**, E-clip **66**, and knob **67**. Thrust washer **64** may be any suitable device such as, for example, a commercially known "poly-slider washer". Cam shaft **61** is rotatably supported between main case **11** and mid-cover **30**, one end being supported by bearing bore **28** at the perimeter of recessed part **11***a* of main case **11**, and the other end being rotatably supported by a bore in mid-cover **30**. Open part **29** is formed at the inner perimeter of recess **11***a* at the bearing bore **28** location in order to expose off-cam **63***b* and on-cam **63***c* on scheduling cam **63**.

Switching cam **62**, which may be formed of any suitable material such as, for example, molded synthetic resin, incorporates cylindrical part **62***a* into which cam shaft **61** is press fit, and four upper cams **62***b* that extend radially from the upper portion of shank **62***a* at uniform intervals. The purpose of upper cams **62***b* is to contact flange **52***b* of spring arm **52**. Switching cam **62** also incorporates four lower cams **62***c* that extend radially from the lower portion of shank **62***a* at uniform intervals, the purpose of lower cams **62***c* being to contact flange **51***b* of spring arm **51**. Clutch teeth **62***d* are formed on one axial end of shank **62***a* facing the lower side of scheduling cam **63**. Upper cams **62***b* and lower cams **62***c* form the second cams which, when viewed axially, display a radial offset of approximately 45 degrees between the upper and lower cams.

Scheduling cam **63**, which may be formed of any suitable material such as, for example, molded synthetic resin material, is constructed approximately the same as switching cam **62**, and includes cylindrical shank **63***a* into which cam shaft **61** is inserted, and four off-cams **63***b* that extend radially at uniform intervals from the upper perimeter of cylindrical shank **63***a*. The purpose of off-cams **63***b* is to contact clip finger **17***c* of scheduling clip **17** (hereafter referred to only as clip finger **17***c*) when scheduling clip **17** is tipped downward toward dial **4**. Scheduling clip **17** contacts four on-cams **63***c* that extend radially at uniform intervals from the perimeter of the lower end of cylindrical shank **63***a* toward switch cam **62**, the purpose of on-cams **63***c* being to contact clip finger **17***c* when scheduling clip **17** is tipped upward. Clutch member **63***d*, which engages clutch member **62***d*, is provided at the other end of shank **63***a* (the end facing switch cam **62**). Off-cams **63***b* and on-cams **63***c* combine to form the first cam which, when viewed axially, demonstrates a radial offset of approximately 45 degrees between the two cams.

Cam switch assembly **60** is assembled by first press fitting cam shaft **61** into the hole in cylindrical shank **62***a* with clutch member **62***d* facing upward, and then pressing switching cam **62** over the bottom portion of cam shaft **61**. Cam shaft **61** is then inserted into the hole in shank **63***a*, with clutch member **63***d* facing downward, thereby resulting in scheduling cam **63** being movable in the axial direction of cam shaft **61**. Thrust washer **64** and coil spring **65** are then placed over cam shaft **61** after which E-clip **66** is secured in the groove (not shown in the drawing) on cam shaft **61**. In this assembled condition, coil spring **65** presses scheduling cam **63** against switching cam **62** with clutch member **62***d* (of switching cam **62**) engaged with clutch member **63***d* (of scheduling cam **63**). Moreover, scheduling cam **63** is not able to move freely in the axial direction on cam shaft **61** as a result of being pressurized against switching cam **62** by coil spring **65**, thus preventing unnecessary movement of cam shaft **61**.

The clutch mechanism is formed from clutch member **62***d* of switching cam **62** and clutch member **63***d* of scheduling cam **63**. When dial **4** rotates clockwise, thereby rotating scheduling cam **63** counter-clockwise through contact with clip finger **17***c*, the engagement of clutch member **63***d* (on scheduling cam **63**) against clutch member **62***d* (on switching cam **62**) results in switching cam **62** also rotating counter-clockwise. However, when dial **4** rotates counter-clockwise, thereby rotating scheduling cam **63** in a clockwise direction through contact with clip finger **17***c*, switching cam **62** does not rotate because scheduling cam **63** moves axially upward on cam shaft **61**, in a direction against the pressure of coil spring **65**, to a point where clutch member **63***d* (on scheduling cam **63**) disengages from clutch member **62***d* (on switching cam **62**).

Cam switch assembly **60** is constructed so that, regardless of the upward movement of scheduling cam **63** on cam shaft **61** that disengages clutch member **63***d* from clutch member **62***d*, the movement resulting from the counter-clockwise rotation of dial **4** causing clip finger **17***c* to push scheduling cam **63** in the clockwise direction, the outwardly raised position of clip head **17***a* brings clip finger **17***c* into contact with on-cam **63***c*, or the inwardly lowered position of clip head **17***a* does not take clip finger **17***c* out of contact with off-cam **63***b*, and the outwardly raised position of clip head **17***a* locates clip finger **17***c* so as not to not interfere with off-cam **63***b*, or the inwardly lowered position of clip head **17***a* locates clip finger **17***c* so as not to interfere with on-cam **63***c*.

Cam shaft **61** of cam switch assembly **60** is rotatably supported between mid-cover **30** and main case **11** with one end extending upward through and supported by bearing bore **28** in mean case **11**. Knob **67** may be attached in any suitable fashion such as, for example, press fitting, gluing, or soldering to the tip of shaft **61** at the end of the shaft extending above bearing bore **28**. Cam switch assembly **60** is easily installed to main case **11** due to its modular construction resulting from cam shaft **61** being press fit into switching cam **62**, scheduling cam **63** being placed over cam shaft **61**, and thrust washer **64** and coil spring **65** being secured on cam shaft **61** by E-clip **66**. Cam switch assembly **60** may also be assembled without E-clip **66** through a structure in which switching cam **62** is press fit over cam shaft **61**, and scheduling cam **63**, thrust washer **64**, and coil spring **65** are assembled to cam shaft **61** with spring **65** being compressed and secured in position by direct contact with the inner surface of main case **11** at the time cam switch assembly **60** is installed between main case **11** and mid-cover **30**. Moreover, while this embodiment specifies a thrust washer installed between scheduling cam **63** and coil spring **65** in order to reduce friction generated therebetween by the pressure applied by coil spring **65**, thrust washer **64** may be omitted if it is determined that the pressure applied by coil spring **65** will not cause excessive friction when scheduling cam **63** rotates. Further, while this embodiment specifies that cam shaft **61** be press fit into switching cam **62** and that scheduling cam **63** rotate freely on cam shaft **61**, cam shaft **61** may be press fit into scheduling cam **63** and switching cam **62** may freely rotate on cam shaft **61**.

With the previously described switch bracket **53** set to the automatic position, turning knob **67** of cam switch assembly **60** counter-clockwise will result in switching cam **62** rotating together with cam shaft **61**, and as shown in FIG. **7***a*, turning knob **67** to an "on" position will result in flange **52***b* of spring arm **52** moving off of the tip of an upper cam **62***b* into the valley between the cams, thus allowing spring arm **52** to be displaced toward spring arm **51** due the tensile energy inherent in spring arm **52**. This brings a lower cam **62***c* of switching cam **62** into contact with flange **51***b* of spring arm **51**, thus bringing contact points **51***a* and **52***a* into mutual contact as a result of the flexing movement of spring arm **51** toward spring arm **52**.

Turning knob **67** in one direction to the "off" position, as shown in FIG. **7***b*, will result in flange **51***b* of spring arm **51** falling off of the cam and into the valley between lower cams **62***c* of switching cam **62**, and thus displacing spring arm **51** in a direction away from spring arm **52** as a result of the tensile energy inherent in spring arm **51**. At the same time, an upper cam **62***b* of switching cam **62** comes into contact with flange **52***b* of spring arm **52**, thus flexing spring arm **52** in a direction away from spring arm **51** to separate contact points **51***a* and **52***a*. Furthermore, turning knob **67** in a direction opposite to the counter-clockwise direction of cam shaft **61**, as driven by contact with clip finger **17***c* of scheduling clip **17** on the perimeter of dial **4**, will bring flanges **51***b* and **52***b* (of spring arms **51** and **52** which are not in mutual contact) against the ends of lower cam **62***c* and upper cam **62***b* respectively and prevent cam shaft **61** from rotating, thus allowing knob **67** to be turned only in a counter-clockwise direction. Because dial **4** does not turn when knob **67** is manually rotated, clutch member **63***d* ratchets against clutch member **62***d* of switch cam **62**, thus preventing the rotation of scheduling cam **63**. It is easy to determine the open or closed condition of contact points **5** in relation to the position of knob **67** due to an arrow marking on the end face of knob **67** and "on" and "off" markings provided on the front of main case **11**. Furthermore, while this embodiment specifies knob **67** to manually move contact points **5** to "on" and "off" positions, knob **67** may be omitted if a manually controlled "on" and "off" operation is not required.

The following will describe clock mechanism **1** which includes primarily dial **4**, sub-dial scale **18**, pointer **19**, and sub-dial **20**.

The dial **4** structure includes dial base **15**, dial cover **16**, and multiple scheduling clips **17**. Dial base **15**, which may be formed of any suitable material such as, for example, molded synthetic resin, includes dome-shaped platform **15***a* in which bearing bore **15***b* is formed at the center for the insertion of cylindrical bearing boss **11***b* which extends from the center of recess **11***a* in main case **11**. Dial base **15** also includes perimeter lip **15***c* that extends upward from the sidewall of platform **15***a*. Dial cover **16**, which may be formed of any suitable material such as, for example, a molded synthetic resin, includes circular plate-shaped perimeter flange **16***a* located at platform **15***a*, perimeter wall **16***b* extending downward from the edge of perimeter flange **16***a*, and lock finger **16***c*, formed on the underside of perimeter flange **16***a*, that locks to orifice **15***d* provided on dial platform **15**. Scheduling clip **17**, an h-shaped clip that may be formed of any suitable material such as, for example, molded synthetic resin, includes clip head **17***a*, L-shaped clip leg **17***b* that extends downward from clip head **17***a*, and clip finger **17***c* that extends outward beneath clip head **17***a*. Multiple scheduling clips **17** (**96** in this embodiment) are placed along the perimeter of dial platform **15**, and are able to swing thereon due to the horizontally extending portion of each clip leg **17***b* inserted between dial base **15** and the lower edge of perimeter wall **16***b* of dial cover **16**. More particularly, tipping clip head **17***a* of scheduling clip **17** downward (toward the center of dial base **15**) results in the tip of clip finger **17***c* moving upward into contact with off-cam **63***b* of scheduling cam **63**, and tipping clip head **17***a* upward and outward results in the tip of clip finger **17***c* moving downward into contact with off-cam **63***b* of scheduling cam **63**. Moreover, round hole **16***d* is openly formed within perimeter flange **16***a* of dial cover **16** concentric with bearing bore **15***b* in dial base **15**, and a 24-hour scale is provided around the perimeter of perimeter flange **16***a*, in relation to clips **17**, said scale being marked off in specific time increments such as, for example, fifteen minute increments.

Dial **4** is housed within recess **11** a by placing bearing bore **15***b* of dial base **15** over bearing boss **11***b* of in main case **11**, and engaging a lock ridge (not shown in the drawings) formed on the inner perimeter of bearing bore **15***b* to bearing boss **11***b*, thus attaching dial **4** to main case **11** in a way that allows the rotating movement of dial **4** in a clockwise or counter-clockwise direction as viewed from above. Further, gear **40***a* of mushroom gear **40** projects through shaft orifice **11***c*, which is formed in the floor of recess **11***a*, and extends from front surface of main case **11** to mesh with gear **15***e* formed on the rear surface of platform **15***a* of dial base **15**. Torque from motor **2** is conveyed to mushroom gear **40** through gearwheel transmission **3**, thus dial **4** rotates together with mushroom gear **40**.

A circular recess is formed within perimeter flange **16***a* of dial cover **16** within which circular plate-shaped sub-dial scale **18** is fixedly inserted so as not to rotate with respect to case **11**. In other words, sub-dial scale **18** does not rotate. Hole **18***a* is formed in the center of sub-dial scale **18**, and external gear **18***b* is concentrically formed around hole **18***a*. Moreover, a twelve hour time scale is inscribed on the upper surface of sub-dial scale **18** in specific time increments.

Sub-dial **20** is a dome-shaped member made from any suitable material such as, for example, transparent synthetic resin. Indicator line **21** is formed on the upper surface of sub-dial **20**, and orifice **20***a*, a small approximately oval-shaped opening when viewed from above, is formed in the approximate center of the upper surface. By securing orifice **20***a* to tip **24***a* of step shaft **24** (tip **24***a* being formed to a small approximate oval-shape as viewed from above), sub-dial **20** and step shaft **24** become a single structure through which sub-dial **20** rotates in unison with step shaft **24**. Step shaft **24** projects upward through orifice **20***a* in sub-dial **20**, and lock ring **22** is secured to the tip of step shaft **24** to prevent the detachment of sub-dial **20**. Moreover, sub-dial **20** may be press fit or bonded to step shaft **24** and thus eliminate the need for lock ring **22**. Also, this embodiment specifies the attachment of decorative cap **23** to the upper surface of sub-dial **20** to visibly cover lock ring **22** and the tip of step shaft **24** at least to improve appearance.

Pointer **19**, which is formed by mutually meshed external and internal gears **18***b* and **19***a*, is rotatably supported between sub-dial scale **18** and sub-dial **20**. A circular boss (not shown in the drawings) formed on the underside of sub-dial **20** joins to the hole in the center of pointer **19**, and due to the circular boss being eccentrically aligned to step shaft **24**, pointer **19** orbits (eccentric rotation) around the perimeter of step shaft **24** while rotating itself. Because the number of teeth on outer and inner gears **18***b* and **19***a* are established at a ratio that advances pointer **19** through a one hour time increment (approximately 30 degrees) for each rotation of sub-dial **20**, the time scale of sub-dial scale **18**, pointer **19**, and indicator line **21** combine to form a twelve hour clock able to display the current time.

The following will describe operation of the time switch of the present invention. Dial **4** rotates in a clockwise direction at a uniform speed with one or more scheduling clips **17** tipped outward at the desired position corresponding to the time during which the connected electrical load is be operated. As shown in FIG. **6***a*, clip fingers **17***c* extend from the perimeter of dial **4** and are thus able to press against off-cam **63***b* and on-cam **63***c* of scheduling cam **63**, which is exposed through open part **29**, and thus turn cam shaft **61** in 45 degree increments.

As shown in FIG. **7***b*, with clip head **17***a* raised outward and contact points **51***a* and **52***a* separated, clip finger **17***c* contacts on-cam **63***c* at the lower end of scheduling cam **63** and thus rotatably drives cam shaft **61** through a 45 degree arc. This results in upper cam **62***b* of switching cam **62** separating from flange **52***b* of spring arm **52**, and lower cam **62***c* pressing against flange **51***b* of spring arm **51** to flex spring arm **51** toward spring arm **52**, a movement that connects contact points **51***a* and **52***b*.

With contact points **51***a* and **52***a* in mutual contact, clip finger **17***c*, as shown in FIG. **7***a*, presses against upper positioned off-cam **63***b* (in this case, clip head **17***a* of scheduling clip **17** is tipped down and inward) which results in cam shaft **61** rotating through a 45 degree arc that allows flange **51***b* on spring arm **51** to fall off of lower cam **62***c* of switching cam **62**, thus allowing spring arm **51** to spring back in a direction away from spring arm **51**. At the same time, upper cam **62***b* presses against flange **52***b* of spring arm **52**, thus causing spring arm **52** to flex away from spring arm **51** and separate contact points **51***a* and **52***a*.

Although scheduling clip **17** operates through the above described mechanism to activate the time at which it is desired to operate the desired electrical load, sub-dial **20** may still be manually rotated in a clockwise or counter-clockwise direction to set the current time.

When sub-dial **20** is manually turned in the clockwise direction (the same direction sub-dial **20** is driven by motor **2**), ninth shank gear **41** also attempts to rotate clockwise through its connection to sub-dial **20** through step shaft **24**. Because the gears ranging from first shank gear **31** (which is attached to the output shaft of motor **2**) to ninth drive gear **39** are in mesh, however, ninth drive gear **39** cannot be manually rotated at a speed greater than that at which it is driven by motor **2**. Therefore, pawls **41***a* of ninth shank gear **41** flex and ride over ratchet teeth **39***a* in order to allow ninth shank gear **41** to disconnect from ninth drive gear **39**, thus resulting in only mushroom gear **40** rotating counter-clockwise in mesh with pinion gear **41***b* of ninth shank gear **41**. The counter-clockwise rotation of mushroom gear **40** drives dial **4** in a clockwise direction, thereby allowing the time to be set by turning sub-dial **20** to the desired time setting. Furthermore, contact points **5** will open and close at this time through the contact of clip fingers **17** with off-cam **63***b* and on-cam **63***c* on scheduling cam **63** as a result of scheduling clips **17** protruding from the perimeter of rotating dial **4**.

Conversely, if sub-dial **20** is manually turned in a counter-clockwise direction (a direction opposite to that driven by motor **2**), ninth shank gear **41** will attempt to turn counter-clockwise due to its connection to sub-dial **20** through step shaft **24**, but because first shank gear **31** (which is attached to the output shaft of motor **2**) through ninth drive gear **39** are in mesh, and because the rotating direction of fourth gear **34** is restricted by rotational restrictor cam **44**, ninth drive gear **39** is prevented from turning in a direction opposite to that of motor **2** due to the tip surfaces of pawls **41***a* pressing against the flanks of ratchet teeth **39***a*. If the torque applied to sub-dial **20** is greater than the torque applied to ninth drive gear **39** from motor **2**, and if the torque is strong enough to cause pawls **41***a* to flex and ride over ratchet teeth **39***a*, ninth shank gear **41** will turn counter-clockwise disengaged from pawls **51***a*. In other words, the operation of pawls **41***a* against ratchet teeth **39***a* generates greater resistance when sub-dial **20** is manually turned in a direction opposite to the direction driven by motor **2** than when manually turned in the same direction as driven by motor **2**. Moreover, as previously noted, only mushroom gear **40** rotates clockwise in mesh with pinion gear **41***b* on ninth shank gear **41** when dial **4** is turned counter-clockwise, thus allowing the time to be set by manually turning sub-dial **20** to the desired time setting. Furthermore, while clip fingers **17***c*, which project from the perimeter of sub-dial **4**, will contact off-cam **63***b* and on-cam **63***c* and thus turn scheduling cam **63** clockwise as sub-dial **4** rotates, switching cam **62** will not rotate due to the disengagement of clutch member **63***d* from clutch member **62***d*, and thus the opening or closing of contact points **5** is prevented. FIG. **8** illustrates four pawls **41***a* shaped in the form of bended spokes. The turning of ninth shank gear **41** in a direction opposite to that driven by motor **2** (clockwise when viewed from below) results in pawls **41***a* contacting the flanks of ratchet teeth **39***a* at a more acute angle, and thus become more resistant to flexing. Therefore, it becomes necessary to carefully establish the tip angles of pawl **41***a*, the flank angles of ratchet teeth **39***a*, and the thickness of pawls **41***a* in order to prevent pawls **41***a* from buckling.

As a result of locating the ratchet mechanism within the power transmission path of gearwheel transmission **3**, ninth drive gear **39** (which is driven by motor **2**) is able to rotatably drive ninth shank gear **41** and thereby rotate dial **4** and sub-dial **20** when the torque applied against ninth drive gear **39** (on the motor side) by mushroom gear **40** (on the dial side) is not sufficient to cause slipping of the ratchet mechanism. Moreover, in cases where sub-wheel **20** is manually turned in a clockwise or counter-clockwise direction, the rotation of sub-dial **20** and ninth shank gear **41** causes the ratchet mechanism to slip, thus preventing the torque of rotating ninth shank gear **41** from being conveyed to ninth drive gear **39**. Therefore, the time can be set by turning sub-dial **20** in either a clockwise or counter-clockwise direction because only dial **4** is rotated. More torque must be applied to turn sub-dial **20** in a direction opposite to that driven by motor **2** as compared to the torque required to turn sub-dial **20** in the same direction as driven by motor **2**. Thus, the need to apply increased torque conveys a feeling of increased resistance which makes it easy to determine if the time should be set by advancing sub-dial **20** or turning it back. Furthermore, when sub-dial **20** is turned in a counter-clockwise direction, the disengagement of the clutch mechanism in cam switch assembly **60** allows scheduling cam **63** to turn freely, disconnected from cam switch assembly **60**. Because switching cam **62** does not rotate when dial **20** is turned counter-clockwise, pressure is not applied against swing arms **51** and **52** when their operation is not required, thus contact points **5** do not open or close, and the probability of damaging swing arms **51** and **52** is reduced. Moreover, the structure of gearwheel transmission **3** is not limited to that described in this embodiment, but may take the form of any power transmission structure in which a ratchet mechanism is incorporated between motor **2** and sub-dial **20**. Furthermore, gearwheel transmission **3** may be structured to drive dial **4** and sub-dial **20** in a counter-clockwise direction.

The structure of the ratchet mechanism is not limited to that in which triangular ratchet teeth **39***a* are formed on the inner perimeter of a circular recess on the rear of ninth drive gear **39**, four L-shaped pawls **41***a* extending in a bended spoke pattern from ninth shank gear **41**, and the tips of rectangular plate-shaped pawls **41***a* contact ratchet teeth **39***a* at approximate angle α (e.g. 45 degrees) with respect to radial intersect line **L1** at the base line of ratchet teeth **39***a*. The ratchet mechanism may also be constructed, for example, as illustrated in FIGS. **9***a* and **9***b*. In this configuration, ninth shank gear **41** includes four S-shaped pawls **41***c* that extend at uniform intervals from the perimeter of the shank part, and the triangular-shaped tips of pawls **41***c* contact ratchet teeth **39***a* on a line approximately aligned with the radial intersection at the base line of ratchet teeth **39***a*. While this type of ratchet mechanism operates in a similar manner to the ratchet mechanism shown in FIG. **8**, pawls **41***c* are, in the FIG. **9** configuration, able to flex more easily as a result of their contacting ratchet teeth **39***a* in a direction approximately aligned with the radial intersection at the base line of ratchet teeth **39***a*. Further, ratchet teeth **39***a* do not apply pressure in a direction that would tend to buckle pawls **41***c* because the flanks of ratchet teeth **39***a* push against the tips of pawls **41***c* at a 45 degree acute angle. This construction also provides relative freedom in establishing the flank angle of ratchet teeth **49***a*, the end face angle of pawls **41***c*, and the thickness of pawls **41***c*. In this configuration, ratchet teeth **39***a* and pawls **41***c* are also constructed to generate greater resistance when sub-dial **20** is turned in a direction opposite to the direction driven by motor **2** as compared to the direction that sub-dial **20** is driven by motor **2**.

FIGS. **10***a* and **10***b* illustrate another type of ratchet mechanism which may incorporate ratchet ring **41***e* which is connected to the shank part of ninth shank gear **41** through spoke parts **41***d*. Triangular pawls **41***f*, which mesh with ratchet teeth **39***a*, are formed on ratchet ring **41***e* at the approximate mid-point between spoke parts **41***d*. In this structure, ratchet teeth **39***a* are asymmetrical in that the flanks of each ratchet tooth are formed differently with respect to line **L1** which is the approximate radial intersection with the base line of ratchet teeth **39***a*. The tooth flank to the right of line **L1** is inclined at angle α with respect to line **L1**, and the tooth flank to the left of line **L1** is inclined at angle β with respect to line **L1**, and angle β>angle α. Each pawl **41***f* on ratchet ring **41***e*, however, has a symmetrical shape whereby the angles on the left and right sides of line **L1**, which is the approximate radial intersection with the base line of ratchet teeth **39***a*, are the same.

When sub-dial **20** is manually turned in the clockwise direction (the same direction as driven by motor **2**), ninth shank gear **41** attempts to turn clockwise along with sub-dial **20** due to gear **41** being fixedly connected to step shaft **24** to which sub-dial **20** is attached. However, as the gearwheels from first shank gear **31** to ninth drive gear **39** are in mesh, and as ninth drive gear **39** cannot be rotated faster in the same direction than the speed at which it is driven by motor **2**, pawls **41***e* ride over ratchet teeth **39***a* due to the flexing of ratchet ring **41***e*, thereby causing ninth shank gear **41** to rotate freely from its disconnection with ninth drive gear **39**. This results in only mushroom gear **40**, which is meshed to pinion gear **41***b*, rotating in the counter-clockwise direction. Sub-dial **20** can thus be turned to the desired time setting due to the clockwise turning of dial **4** and the counter-clockwise turning of mushroom gear **40**.

When sub-dial **20** is manually turned in the counter-clockwise direction (the opposite direction to that driven by motor **2**), ninth shank gear **41** attempts to turn counter-clockwise along with sub-dial **20** due to its connection to step shaft **24** to which sub-dial **20** is attached. As previously noted, however, due to ninth drive gear **39** not being able to rotate in a direction opposite to that driven by motor **2**, applying a level of torque to sub-dial **20** greater than that applied by motor **2** will result in pawls **41***f* riding over ratchet teeth **39***a* due to the flexing of ratchet wheel **41***e*, thereby resulting in ninth shank gear **41** rotating counter-clockwise disconnected from ninth drive gear **39**. Because only mushroom gear **40** turns in the clockwise direction as a result of its meshed connection to pinion gear **41***b* of ninth shank gear **41**, and because dial **4** turns in the counter-clockwise direction, sub-dial **20** can be turned to set the desired time. Furthermore, when sub-dial **20** is manually turned, more torque must be applied to turn it in a direction opposite to that driven by motor **2** as compared to that required to turn it in the same direction as driven by motor **2**. A feeling of greater resistance is felt when turning sub-dial **20** in the direction opposite to that driven by motor **2**, thus making it easy to determine if the time should be set by continuing to advance sub-dial **20** or turning it back in the other direction. Moreover, as shown in FIGS. **10***a* and **10***b*, each pawl **41***f* of ratchet ring **41***e* is symmetrically formed to the left and right sides of line L**1**, thereby resulting in ratchet ring **41***e* flexing the same amount regardless of the direction that ninth shank gear **41** turns. However, because the right and left flanks of ratchet teeth **39***a* are asymmetrically formed to flank angles α and β (β>a), more torque is required to turn sub-dial **20** in a direction opposite to that driven by motor **2** than in the direction driven by motor **2**, thus making it easy to establish the amount of torque that will be required to turn sub-dial **20**. Ratchet teeth **39***a* and ratchet ring **41***e* thus form a mechanism able to generate resistance which can be felt when manually turning sub-dial **20**.

Furthermore, in this embodiment, the number of clutch teeth **62***d* on switching cam **62** and clutch teeth **63***d* on scheduling cam **63** (as shown in FIG. **6**) are the same (8 teeth) as the combined number of off-cams **63***b* and on-cams **63***c* as shown in FIGS. **6***a* and **6***b*. As a result of there being eight clutch teeth **62***d* and **63***d*, the manual or motor **2** driven rotation of dial **4** in the clockwise direction, after turning dial **4** manually in the counter-clockwise direction, results in clip finger **17***c* of clip **17**, which extends from the perimeter of dial **4**, pressing against off-cam **63***b* and on-cam **63***c* to open and close points **5**.

In other words, when dial **4** is rotated forward, either manually or by the operation of motor **2**, clip finger **17***c* of scheduling clip **17**, which extends from the perimeter of dial **4**, presses against on-cam **63***c* or off-cam **63***b* of scheduling cam **63** which results in the rotation of scheduling cam **63** and switching cam **62**. While contact points **5** open and close from the rotation of upper cam **62***b* or lower cam **62***c* on switching cam **62**, because switching cam **62** and scheduling cam **63** are mounted to a single cam shaft **61**, the total number of upper cams **62***b* and lower cams **62***c* (8 cams) on switching cam **62** must be the same as the total number of off-cams **63***b* and on-cams **63***c* (eight) of scheduling cam **63**. Because this embodiment specifies that there be four off-cams **63***b* and four on-cams **63***c* on scheduling cam **73**, cams **63***c* and **63***b* each rotate 45 degrees when struck by clip finger **17***c*. For example, if there were to be three off-cams **63***b* and three on-cams **63***c* on scheduling cam **63**, scheduling cam **63** would rotate 60 degrees when an off-cam **63***b* or on-cam **63***c* is struck by clip finger **17***c*. Contact points **5** could not be opened or closed if switching cam **62** were to rotate 60 degrees from the rotation of scheduling cam **63**. Therefore, in this embodiment, the total number of upper and lower cams **62***b* and **62***c* on switching cam **62** is established as a whole integer multiple (1-to-1 in this embodiment) of the total number of off-cams **63***b* and on-cams **63***c* of scheduling cam **63** so that switching cam **62** turns to the same rotational angle as scheduling cam **63** to bring contact points **63** in and out of mutual contact. Moreover, switching cam **62** and scheduling cam **63** may have a mutually different number of cams if rotatably supported on separate shafts.

In addition, when dial **4** is manually turned in the counter-clockwise direction, the clutch will slip to allow only scheduling cam **63** to turn in 45 degree increments. However, if the number of clutch teeth **62***d* on switching cam **62** and the number of clutch teeth **63***d* on scheduling cam **63** are established as a whole integer multiple of the total number of off-cams **63***b* and on-cams **63***c* on scheduling cam **63** (a multiple of 1 in this embodiment), clutch teeth **62***d* of switching cam **62** and clutch teeth **63***d* of scheduling cam **63** will interlock when scheduling cam **63** completes its arc of rotation. Therefore, the subsequent manual or powered (by motor **2**) rotation of dial **4** in the clockwise direction will result in clip finger **17***c* of scheduling clip **17**, which projects from the perimeter of dial **4**, pressing against off-cam **63***b* or on-cam **63***c* of scheduling cam **63**, and therefore making it possible to quickly rotate switching cam **62**.

In other words, with contact points **5** having been switched to their "on" state by an "on" clip finger **17***c*, dial **3** is manually rotated in the counter-clockwise direction (the opposite direction to that driven by motor **2**) so that the "on" clip finger **17***c* that switched contact points **5** to their "on" state passes scheduling cam **63**, an "off" clip finger **17***c* passes scheduling cam **63**, and the next "on" clip finger **17***c* moves up to scheduling cam **63**. During this time, scheduling cam **63** rotates approximately 45 degrees from contact with the "on" clip finger **17***c* that switched contact points **1** to their "on" state, and a further approximate 45 degrees from contact with the "off" clip finger **17***c*, thus rotating a total of 90 degrees while contact points **5** have remained in their "on" state, and with an "on" clip finger **17***c* at scheduling cam **63**. Because clutch teeth **62***d* of switching cam **62** are engaged with clutch teeth **63***d* of scheduling cam **63**, the manual or powered (by motor **2**) rotation of dial **4** in the clockwise direction (the direction driven by motor **2**) will cause an "off" clip finger **17***c* to press against off-cam **63***b* of scheduling cam **63**, thus resulting in scheduling cam **63** and switching cam **62** rotating approximately 45 degrees to switch contact points **5** to their "off" state.

To offer an additional example, with contact points **5** having been switched to their "on" state by an "on" clip finger **17***c*, dial **4** is manually turned in the counter-clockwise direction to the extent that "on" clip finger **17***c*, which has just switched contact points **5** to their "on" state, moves past scheduling cam **63**, an "off" clip finger **17***c* moves past scheduling cam **63**, the next "on" clip finger **17***c* moves past scheduling cam **63**, and the next "off" clip finger **17***c* is brought up to the switching position. During this time, scheduling cam **63** rotates approximately 45 degrees from contact with the clip finger **17***c* that switched contact points **5** to their "on" state, a further approximate 45 degrees from contact with the next "off" clip finger **17***c*, and a further 45 degrees from contact with the next "on" clip finger **17***c*. Scheduling cam **63** has thus rotated a total of approximately 135 degrees with contact points **5** remaining in their "on" state and with an "off" clip finger **17***c* now at the scheduling cam **63** position. If it is determined at this time that an "off" clip finger **17***c* is at scheduling cam **63**, and it is desired that contact points **5** be switched to their "off" state, this can be done by manually turning knob **67** which, in this embodiment, allows contact points **5** to be quickly and forcefully opened or closed. After contact points **5** have been switched to their "off" state through the manual turning of knob **67** (as a result of clutch teeth **62***d* of switching cam **62** being engaged to clutch teeth **63***d* of scheduling cam **63**) the manual or powered (by motor **2**) rotation of dial **4** in the clockwise direction (the direction driven by motor **2**) results in an "on" clip finger **17***c* contacting on-cam **63***c* of scheduling cam **63**, thus resulting in scheduling cam **63** and switching cam **62** rotating approximately 45 degrees to switch contact points **5** to their "on" state.

The following describes the time setting operation if knob **67** (which allows contact points **5** to be quickly and manually opened or closed) were omitted from the time switch. At a time when contact points **5** have been switched to their "on" state by clip finger **17***c* coming to the switching position, it is not difficult to set the time by manually turning dial **4** counter-clockwise past the desired time setting to the next "on" clip finger **17***c*, and then rotating dial **4** clockwise to the desired time setting. Also, at a time when contact points **5** have been switched to their "off" state by clip finger **17***c*, and dial **4** is manually turned counter-clockwise to set the desired time, it is not difficult to turn dial **5** past the desired time setting to the next "off" clip finger **17***c* switching position, and then turn dial **4** manually clockwise to the desired time setting.

Further, while this embodiment specifies that the respective number of clutch teeth **62***d* and **63***d* on switching cam **62** and scheduling cam **63** be equal, switching cam **62** may be formed with sixteen clutch teeth **62***d*, a number double that of the number of teeth (eight) of off-cam **63***b* and on-cam **63***c* of scheduling cam **63**. In this case, even though there are eight clutch teeth **63***d* on scheduling cam **63** (the same number of teeth on off-cam **63***b* and on-cam **63***c*), turning dial **4** manually in the counter-clockwise direction will result in clip finger **17***c*, which projects from the perimeter of dial **4**, turning only scheduling cam **63** to a rotational angle (approximately 45 degrees) corresponding to two clutch teeth **63***d* of switching cam **62**. When scheduling cam **63** stops turning, clutch teeth **62***d* and **63***d* of switching cam **62** and scheduling cam **63** engage, after which the manual or powered (by motor **2**) rotation of dial **4** in the clockwise direction makes it possible for switching cam **62** to rotate simultaneously with scheduling cam **63** at the time scheduling cam **63** begins rotating through contact with finger clip **17***c* which projects from the perimeter of dial **4**.

By establishing the total number of clutch teeth **62***d* on switching cam **62** as a whole integer multiple of the total number of clutch teeth **63***d* on scheduling cam **63**, the manual or powered (by motor **2**) rotation of dial **4** in the clockwise direction, after dial **4** has been manually turned in the counter-clockwise direction, results in the mutual engagement of clutch teeth **62***d* and **63***d* of switching cam **62** and scheduling cam **63**, thus making it possible to open or close contact points **5** through the operation of clip finger **17***c* of a scheduling clip **17** positioned at a time setting subsequent to the present time. Moreover, the provision of sixteen clutch teeth **62***d* on switching cam **62**, a number twice that of the eight clutch teeth **63***d* on scheduling cam **63** (the same number of clutch teeth as the total number of clutch teeth on off-cam **63***b* and on-cam **63***c*), will provide the same effect as noted previously.

The following will describe a second embodiment of the present invention with reference to FIGS. **12** and **13**. The first embodiment specifies knob **67** (through which cam switch assembly **60** can be manually turned) quickly open or close the contact points. This second embodiment, however, eliminates knob **67**. Also, while the first embodiment describes time switch **10** as being a single structure separated into main case **11** in which clock mechanism **1** is housed, and sub-case **12** in which the input-output terminal part is housed, the second embodiment houses the clock mechanism and input-output terminal part in the same space, and does not use an external case in which time switch **10** is housed. Moreover, FIG. **13** is a block diagram describing the circuit structure used by the second embodiment in which contact points **5** are connected directly to load terminals **T21** and **T22** whereby the on-off operation of contact terminals **5** control the on-off operation of the load. Descriptions of structures, operations, and components of the second embodiment that are identical to those of the first embodiment have been omitted.

Although the invention has been described with reference to an exemplary embodiment, it is understood that the words that have been used are words of description and illustration, rather than words of limitation. Changes may be made within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the invention in its aspects. Although the invention has been described with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed. Rather, the invention extends to all functionally equivalent structures, methods, and uses such as are within the scope of the appended claims.

The present disclosure relates to subject matter contained in priority Japanese Application Nos. 2003-281235, filed on Jul. 28, 2003, and 2003-301914, filed on Aug. 26, 2003, which are herein expressly incorporated by reference in their entireties.

What is claimed is:

1. A time switch comprising:

a switch case,

a dial rotatably attached to the face of said switch case, said dial rotatably driven at a uniform speed through a gearwheel transmission powered by a motor rotating at a uniform speed;

scheduling clips including finger portions which project from the perimeter of said dial to determine a desired operating time;

a cam shaft supported by said switch case;

first cams projecting from the perimeter of a scheduling cam rotatably supported by said cam shaft, said scheduling cam rotatable through contact with respective finger portions of said scheduling clips,

second cams projecting from the perimeter of a switching cam rotatably supported by said cam shaft, said switching cam rotatable in one direction together with said scheduling cam;

contact points that switch between on and off positions relating to the rotation of said second cams provided on said switching cam; and

a ratchet mechanism provided within said gearwheel mechanism that does not slip when torque transmitted from the motor is sufficient to rotatably drive said dial, and slips when said dial is manually turned while being rotatably driven by torque transmitted from the motor.

2. The time switch according to claim **1**, further comprising:

a manually rotatable sub-dial provided within the gearwheel transmission;

wherein said ratchet mechanism is provided between the motor and said sub-dial.

3. The time switch according to claim 1, further comprising:

a mechanism provided to generate greater resistance to rotation of said dial when the dial is manually turned in a direction counter to the direction in which it is turned by the motor.

4. The time switch according to claim 1, the ratchet mechanism comprising:

a disc-shaped member and multiple ratchet teeth formed at uniform intervals along the internal perimeter of a circular depression formed within one side of said disc-shaped member;

a drive gear that rotates in response to rotation of the motor;

a flexible ratchet pawl and a tip portion on said flexible ratchet pawl held in mesh with said ratchet teeth; and

a shank gear that conveys torque from said drive gear to said dial;

wherein said shank gear is rotatably driven by said drive gear, through the ratchet mechanism, by torque transmitted from the motor when said dial is rotatably driven by the motor, said torque being insufficient to disengage the ratchet mechanism, and

wherein said shank gear disconnects from said drive gear due to the manual rotation of said dial conveying torque sufficient to flex said ratchet pawls to the extent of riding over said ratchet teeth.

5. The time switch according to claim 4, further comprising:

a mechanism provided to generate a feeling of greater resistance when said dial is manually turned in a direction opposite to the motor-driven direction as compared to the feeling when said dial is manually turned in the motor-driven direction, said mechanism comprising:

a ratchet pawl tip symmetrically formed on both sides of the approximate radial intersection line at the inner perimeter of the circular depression; and

triangular ratchet teeth having edges intersecting right and left sides of said radial intersecting line at different angles.

6. The time switch according to claim 1, further comprising:

a clutch mechanism, said clutch mechanism comprising:

first clutch teeth formed on the side of said scheduling cam opposing said switching cam;

second clutch teeth formed on said switching cam, said second clutch teeth meshing with said first clutch teeth; and

a pressure applying device to apply pressure to said scheduling cam against said switching cam;

wherein said first and second clutch teeth mutually engage to transfer torque from said scheduling cam to said switching cam when said dial is rotatably driven in the motor-driven direction, and

wherein said first and second clutch teeth mutually disengage to prevent the transfer of torque from said scheduling cam to said switching cam when said dial is turned in a direction opposite to the motor-driven direction.

7. The time switch according to claim 6, wherein the number of said first and second clutch teeth comprises as a whole integer multiple of the number of said first cams of said scheduling cam.

8. The time switch according to claim 6,

said pressure applying device comprising a coil spring;

said scheduling cam is rotatably supported by a cam shaft provided on said switching cam;

said coil spring is positioned over said cam shaft to apply pressure to said scheduling cam against said switching cam; and

a locking clip is joined to a groove formed in said cam shaft to support said coil spring between said scheduling cam and said lock ring.

9. The time switch according to claim 8, further comprising a friction reducing member provided between said scheduling cam and said coil spring.

10. The time switch according to claim 4, wherein said shank gear is formed integrally and in one piece with a supporting shaft.

11. The time switch according to claim 8, wherein said cam shaft is formed integrally and in one piece with said switching cam.

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